The

Tropical Agriculturist

January, 1929.

EDITORIAL

THE MANURING OF PADDY

IN this number of the *Tropical Agriculturist* is reprinted an article on the manuring of paddy in Lower Burma which is of particular interest in that it points the way to the profitable use of artificial fertilisers. Profits have been made possible not only by the discovery of a particularly suitable manure but by the increase of paddy prices and the fall in the price of fertilisers since the war. The fertilisers which proved successful were two forms of the comparatively lately introduced ammonium phosphate, ammophos, the 20—20 grade and the 13—48 grade. These figures show the respective percentages of ammonia and phosphoric acid. In Burma the 20—20 grade has given better immediate effects and the 13—48 grade better residual effects. It will be seen that the profits from the use of the 20—20 grade are considerable; an increase of 47 per cent. of grain has been obtained from a 50 lb. dressing.

The Department of Agriculture, Ceylon, has not failed to realise the importance of obtaining accurate data on the manuring of paddy in Ceylon and during the present *Maha* season carefully designed manurial experiments the results of which will admit of statistical interpretation have been put down at Peradeniya and Galle.

Although the beneficial effects of manuring with green leaves such as *keppitiya (Croton lacciferus)* and with steamed bone meal are widely known and the practice of using steamed bone meal is fairly general in the Southern Province at least, previous experiments have not been sufficiently accurate to give precise figures of profit and loss. Such figures will be obtainable from the new series of experiments now in progress. These experiments have been designed to determine the effect of fertilisers such as sulphate of ammonia, super-phosphate and steamed bone meal both alone and in conjunction with green manures. The effect of the 20—20 grade of ammophos is being tested in a separate series and in view of the Burma figures the results of this series should be particularly interesting and should lead to the trial of the cheaper forms of ammonium phosphates now on the market.

The effect of green manuring of paddy and of puddling in of the green material at different dates is also being investigated at Peradeniya.

The production of paddy in Ceylon may be increased by the use of pedigree seed, by a more certain water-supply, by more efficient methods of cultivation and by manuring. Manuring would appear to be one of the simplest means of increasing yields but the problem of manuring paddy in Ceylon is complex. The price of paddy; the supply, transport charges and unit costs of manures; the effect of manures on lodging; these are matters which must all be considered, and it must be remembered that cultivators under a share system of tenancy will not be willing to bear the whole or a large proportion of the cost of the manure. But, if manuring is definitely shown to be profitable and if tenants can enter into satisfactory arrangements with their landlords over the supply of manures, a considerable increase in the outturn of paddy will be assured.

ORIGINAL ARTICLES.

A NOTE ON CONTOUR TERRACING FOR RUBBER.

T. H. HOLLAND, DIP. AGRIC., (WYE)
MANAGER, EXPERIMENT STATION, PERADENIYA

IN an article in *The Tropical Agriculturist* of September 1927 entitled "Contour Terracing on the Experiment Station, Peradeniya," the writer set forth the details and results of a piece of terracing work done on the station in 1927 and drew certain conclusions therefrom. Since then a good deal more work of this nature has been carried out, and it is thought that a further note may prove of interest.

It is not proposed in this brief note to consider special methods of terracing such as the trench method evolved by Mr. F. Denham Till, but only to deal with the construction of plain earth contour platform sloped back into the hill. Contour terracing for rubber has passed the experimental stage, but there is nevertheless, a number of points to be taken into consideration which may not strike the novice who is unfamiliar with the work.

It may be stated at the outset that, given a uniform slope, some of the problems here discussed are capable of mathematical solution. Since, however, very few slopes are uniform over any considerable area, and since such a method of approach will not appeal to many practical men, the writer has not attempted the introduction of mathematics.

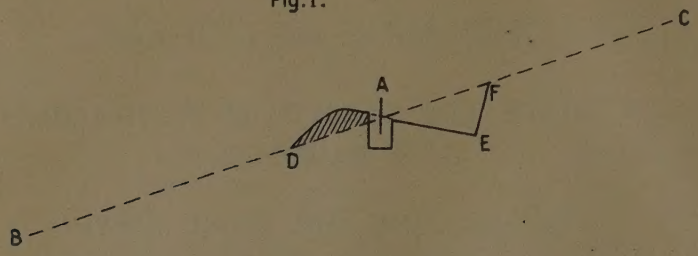
Before starting to terrace a clearing the following points must be decided:

1. Whether holing is to be done before terracing or *vice versa*.
2. The distance apart of the terraces and the spacing between plants in the terrace.
3. The width and the slope of the terrace.

1. *Whether holing is to be done before terracing or vice versa.* Both systems have their advantages and disadvantages. If holing is done first there is no difficulty in filling the holes with surface soil; the actual operations of holing and filling are in fact just the same as if no terracing was contemplated. There are

however other problems. One of these is that the position of the plant in the terrace is uncertain and variable.

Fig. 1.



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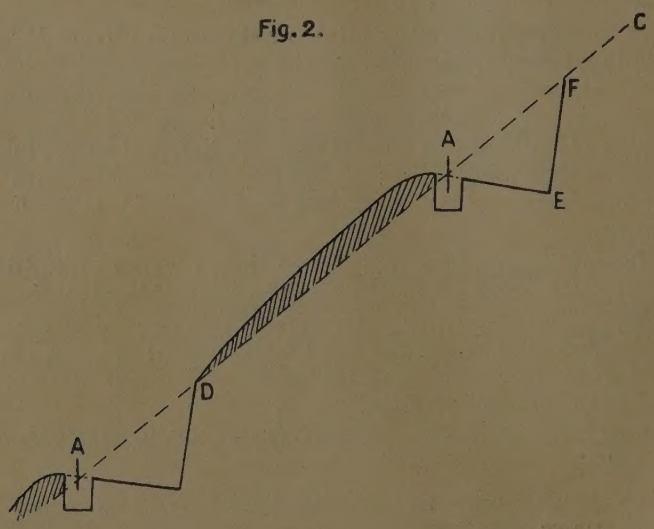
In fig. 1, A represents the peg in the hole, B C the original slope, and D E F the final terrace. B C in this instance is intended to represent a moderate slope and the position of the plant is quite satisfactory.

A steeper slope is depicted in fig. 2.

Fig. 2.



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In this case, owing to the steepness of the slope, the earth thrown out has fallen much further down the hill, as far in fact as the next terrace, and very little has lodged outside the plant which is thus left perched on the edge of the terrace. Should erosion take place at this point there is danger of root exposure at a later date. This state of affairs exists in a ten-acre clearing terraced at Peradeniya where the terraces were dug five feet back

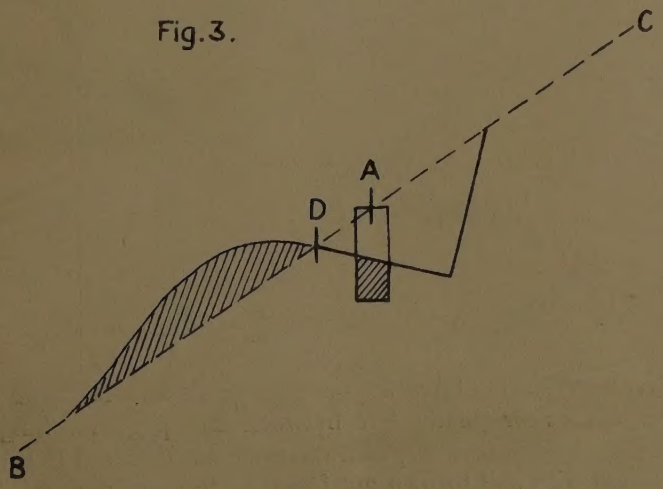
from the pegs marking the holes. The distance of the plants from the edge of the terraces varies considerably, but in most cases is smaller than is desirable. In the case in point the excellent and rapid growth made by *Centrosema pubescens* planted over the face of the terraces has minimised the danger of future root exposure.

A simple remedy for this trouble is subsequently to widen the terrace. In the case depicted in fig. 2, if the terrace had been dug wider in the original instance some of the earth would have fallen on to the terrace below; but if time is allowed for the earth originally thrown out to settle, and possibly be bound by a cover crop, this is not likely to occur. Some of the cover crop would be buried, but it would soon cover up the new soil again.

It may be thought that, since on a steeper slope the cubic contents of the portion of the bank to be cut out (seen in section as the triangle A E F) will be greater than on a more gentle slope, more earth will be thrown outside the plant and there will be sufficient space between the edge of the terrace and the plant. In practice, however, it is found that the increased slipping down the slope of the earth thrown out more than counterbalances the larger quantity of earth.

Another method of overcoming this trouble, which has not as yet been tried at Peradeniya, is suggested in fig. 3.

Fig. 3.



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This is to dig the holes deeper than usual, fill them only partially with surface soil, insert a peg D a certain distance below the peg

A, and instruct the contractor to dig the terrace the specified width from the peg D instead of from the peg A. The depth to which the holes would have to be dug and the proportion of this depth to which they needed to be filled would have to be determined by experiment and would depend on the distance D A. Probably the greatly increased cost and the difficulty in digging such deep holes would rule out this method as a practical proposition.

The question of whether holing and planting or only holing is done before terracing is a subsidiary one. Both methods have been employed at Peradeniya, and the principle is the same in either case. Care is necessary that the plants or stumps are not damaged by earth or stones thrown down from above, but in practice this has not caused much difficulty.

We now come to the second method, terracing first and holing afterwards. This method has the advantage that the holes can be placed in the most desirable position on the terrace, usually at a point about two-thirds of the distance from the back bank to the edge. The difficulty lies in filling the holes with surface soil. Though the cost of filling will always be more in this case, the difficulty is not serious on a gentle slope; on a steep slope it becomes somewhat acute.

Fig. 4.

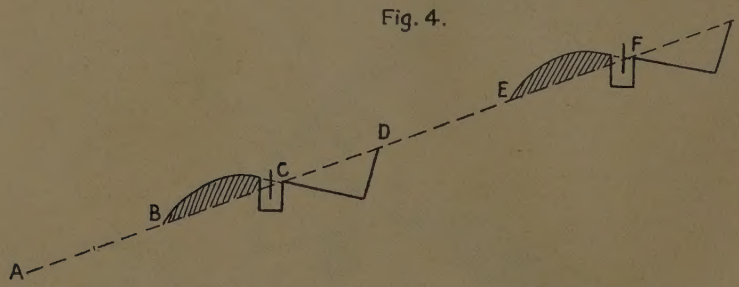

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Fig. 4 represents terracing on a gentle slope. A C and D F are the spaces originally left between the pegs marking the position of the terraces of which the portions B C and E F have been buried with soil thrown out from the terraces above. Surface soil, however, can still be taken from the portions A B and D E, though it will probably be necessary to use baskets.

Fig. 5.

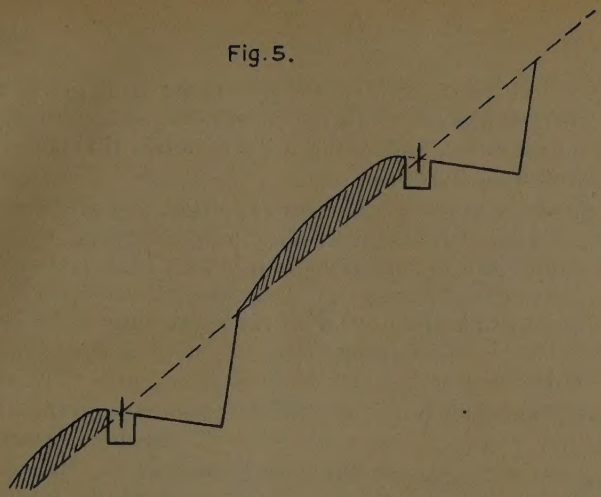

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Fig. 5 represents terracing on a steep slope. In this case, the entire space between the two terraces is covered up with soil thrown from the terraces above, and surface soil can noly be obtained by scraping away this new earth. This may be an extreme case, but the difficulty is a very real one.

It will be understood that the gradient is not the only factor involed: the size of the terraces and their distance apart will influence respectively the amount of earth to be thrown out and the space that will remain uncovered by this earth.

Fig. 6.

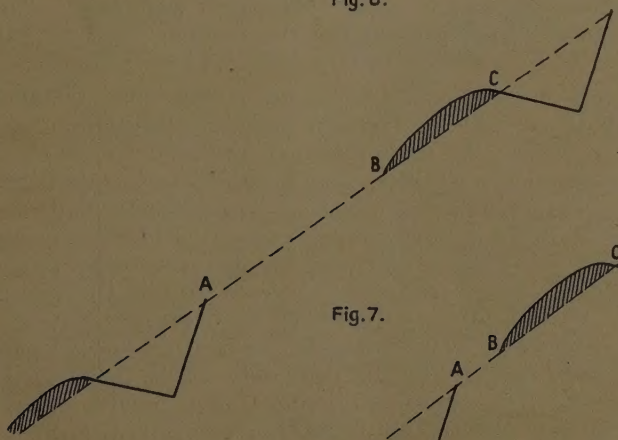
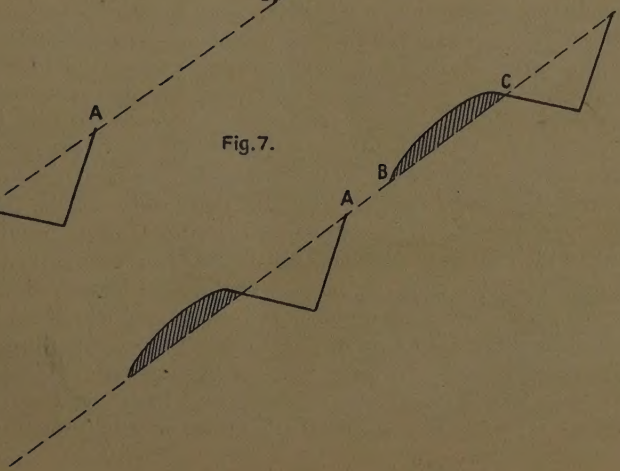


Fig. 7.



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Figs. 6 and 7 represent two slopes of the same gradient with terraces of the same size. In fig. 7, however, the terraces are placed closer together, and, though the distance B C is the same, A B is considerably shorter.

The question of the distance apart of terraces will be further discussed. Time and season are other factors which will influence a decision on this first point. In a case at Peradeniya the expenditure of funds was only sanctioned from April 1st., and the clearing had to be planted with rubber during the south-west monsoon. There was only just time to complete the holing, and terracing had of necessity to be done later.

Briefly the conclusion is that, if the gradient and the distance apart of the terraces are such that a sufficient space from which surface soil may be taken remains between the terraces, and if sufficient time is available, it will probably be found more convenient to terrace first and hole afterwards. If these conditions are not present it will be necessary to hole, and possibly plant, first. The most satisfactory course is to experiment first on a small area.

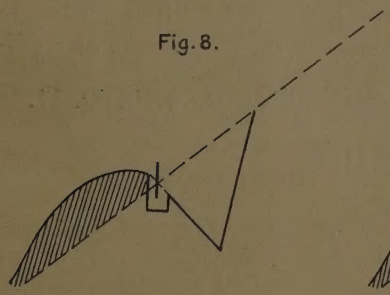
2. *The distance apart of the terraces and the spacing of the plants in the terraces.* The factors which will influence this decision are (a) the number of trees to be planted per acre, (b) the gradient, (c) whether holing or terracing is to be done first. The number of trees per acre to be planted will certainly not be less than 100, and may often be more. In the recent work at Peradeniya the intention was to plant 120 trees per acre. The following distances give approximately this number: 19 ft. x 19 ft. 18 ft. x 20 ft., 17 ft. x 21 ft., 16 ft. x 23 ft., 15 ft. x 24 ft.

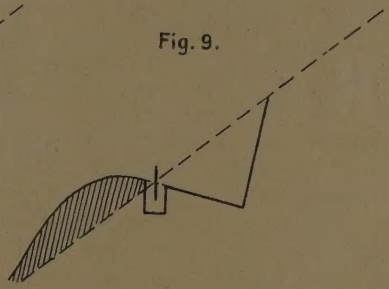
Though all terraces may be started at the same distance apart, this distance will not remain constant throughout the length of the terraces; the undulations of the land will in some cases bring them closer together and in other cases take them further apart. Thus, whatever planting distance is decided upon a slight variation in the number of trees per acre is likely to occur. When the distance between the terraces increases very much, short extra lengths of terrace can be inserted, or odd trees without terraces. A clearing at Peradeniya was terraced with the object of planting 19 ft. x 19 ft., that is, the contour lines of pegs were started 19 ft. apart, and the pegs were 19 ft. apart in the lines. In this case 5 ft. terraces were dug, and even with terraces of this width in some cases in the steeper portions the earth thrown out reached the next terrace. Holing had been done first, so that no great harm resulted. If holing had not been done first, great difficulty would have been experienced in filling the holes with surface soil. In later work (on generally a steeper slope) 20 ft. was left between the terraces and 18 ft. between the plants in the terraces. The width of the terraces was however increased

to 6 ft., and the additional earth thrown out, added to the steeper gradient, more than counterbalanced the extra space between the terraces.

Here again holing had been done first; otherwise filling would have been difficult. If holing after terracing is adopted and if the gradient is at all steep, it is essential to get the terraces as far away from one another as is possible without undue overcrowding of the plants in the terraces. If 120 plants per acre are required, terraces 24 ft. apart and plants 15 ft. apart in the terraces should achieve the desired result. If holing is done first, then terraces 20 ft. or 21 ft. apart and plants 18 ft. or 17 ft. apart in the terraces would in most cases be satisfactory. Again experiment on a small scale is desirable.

3. *The width and slope of the terraces.* Experience indicates that for terraces sloped back at an angle of one in five, 6 feet is the maximum useful width. It is true that a steeper slope will to a certain extent compensate in water-holding capacity for a reduced width, but there are limits to this procedure.





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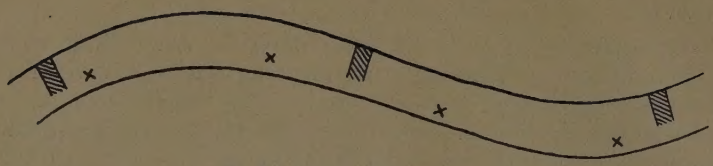
Figures 8 and 9 depict exaggerated cases of two terraces. Fig. 8 shows a narrower terrace more steeply sloped than the one in fig. 9. It will be readily seen that the terrace in fig. 8 will hold up as much water as or more water than the terrace in fig. 9 without overflowing; but the rubber trees would be planted on a steep ridge and root exposure might result at a later date. A six foot terrace with a slope of one in five will be found suitable for most purposes.

OTHER POINTS

1. *Transverse bunds.* Transverse bunds left at intervals will be found very useful in checking lateral flow of water caused by any slight fault in tracing the terraces. At Peradeniya such bunds have been left between every two rubber plants. The arrangement is shown in plan in fig. 10.

Fig. 10.



x = Rubber plants

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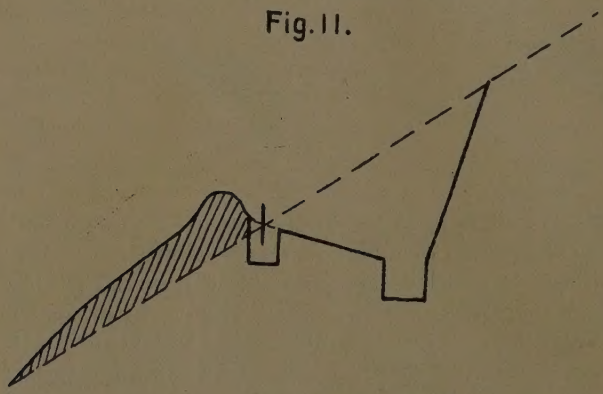
2. *Over-flow of accumulated water.* In exceptional falls of rain an overflow of water may occur at points where, owing to the configuration of the ground, there is a particular accumulation. The damage done by such an overflow may be considerable. In such cases it is necessary to decide whether the construction of a down drain is necessary or whether the case can be met by widening the terraces at these points. Generally the latter course will be worth trying. The earth thrown out in widening the terraces will fill in the channels that have been erroded in the bank and it can be decided after the next heavy fall whether the improvement has been effective. As an additional safe-guard a silt-pit may be dug at the back of the terrace and a bund formed at the outer edge. This is shown in fig. 11.

Fig. 11.



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This procedeure will greatly increase the water-holding capacity of the terrace at such points and will probably check further trouble.

3. *Cost.* At Peradeniya five foot terraces have been dug by local Sinhalese contractors at Rs. 2 75 per chain of 66 feet. and six foot terraces at Rs. 3-50 per chain. The cost per acre at these rates will usually work out at between Rs. 75-00 and Rs. 85-00.

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME

NOTE ON THE RENEWAL OF SCRAPED BARK SURFACES

J. MITCHELL, A.R.C.Sc.,

ORGANISING SECRETARY, RUBBER RESEARCH SCHEME (CEYLON)

IN connection with the treatment of Brown Bast by the scraping method advised in Research Scheme Bulletin No. 48 it has been observed that bark surfaces so scraped renew at a much enhanced rate as compared with the renewal of bark surfaces after tapping. In fact, in a large number of cases where it has been found necessary to effect a scraping for Brown Bast over half the circumference of the tree, it has been observed that the thickness of the renewed bark after a period of one year from the time the surface was scraped has been greater than on the unscraped surface of the tree (tapped panel) after a period of three to four years. Again, it has been observed that the bark after such a scraping has a smoother surface and a softer consistency than the renewed bark after tapping. A sufficient number of observations have been made to satisfy the writer that the scraping method for Brown Bast could usefully be extended to bark surfaces which show extremely slow and irregular renewal. It was anticipated that the long periods of rest given to the trees during the restriction period would bring about a great improvement in the renewal of bark surfaces and in many cases this anticipation has been fulfilled. On the other hand, however, there has been a good deal of disappointment as the results even after prolonged rest have been unsatisfactory. Some reports have been received of better bark renewal having been secured from a course of manuring but other reports indicate that manurial applications have had no appreciable effect on bark renewal. It would appear, therefore, that manuring alone is not sufficient to stimulate the renewal of bark on trees which present a somewhat hide-bound condition and it is considered that in such cases the adoption of a scraping method similar to that for Brown Bast would prove beneficial.

The writer suggests that a thorough trial be given of the scraping method on trees which are known to renew their bark at a slower rate than the normal. The scraping should be carried out exactly as advised in Bulletin No. 48. The same care will be required to avoid wounding and the same precautions should be adopted throughout the treatment.

REPORT ON RUBBER FROM HIGH-YIELDING TREES AT HENERATGODA

AT the request of the Director of Agriculture in Ceylon six samples of rubber from individual trees at Heneratgoda gardens were forwarded for examination in order to judge the value of the trees as "mother" trees.

In forwarding the samples the Director stated that all six trees were amongst the highest yielders at Heneratgoda, two of them growing in plantation No. 1 and four in plantation No. 3. Plantation No. 1 dates from 1877 and was the first in Ceylon. Plantation No. 3 is believed to be composed of thinnings from plantation No. 1 or of cuttings left over in the original nurseries. All trees were tapped on alternate days on a single cut on one-third of the total circumference of the tree.

Each sample consisted of about eighty biscuits of unsmoked sheet varying in size, thickness and colour; some were mouldy. An appreciable amount of serum had exuded between some of the biscuits which were not quite dry. On the whole the amount of moisture in the rubber was less than 1 per cent.

It was stated that in the preparation of the samples the latex was collected at 11 a.m. each day and coagulated with acetic acid. After an interval of twenty hours the coagulum was submitted to "simple rolling to express the bulk of the water". Each biscuit was then soaked in 0·1 per cent. paranitrophenol solution for 30-60 minutes and placed on drying racks for a period of 4-6 weeks.

PLASTICITY TESTS.

The following are the results of plasticity tests on these samples:—

Sample no.	Plantation no.	Tree no.	Length of cut.	Yield (April 1927-March 1928).	Number of grindings through laboratory rolls required to reduce rubber to a standard plasticity*.
			(ins.)	(lb.)	
(1)	(2)	(3)	(4)	(5)	(6)
1402	3	401	32	36·7	48
1403	1	2	46	50·6	57
1404	1	24†	26	49	35
1405	3	400	35½	45·1	46
1406	3	439	34	31·4	49
1407	3	445	39½	36·3	32

The figures in column 6 show that sample No. 1403 is the least and samples Nos. 1404 and 1407 the most plastic. The remaining samples do not differ greatly from each other in plasticity.

* The standard plasticity adopted is the rate of extrusion of 10 cc. per minute under load of 1,000 lb./sq. in. at 85°C.

† Suffering from *Ustulina* disease.

VULCANISATION AND MECHANICAL TESTS.

The following are the results of tests at the optimum tensile strength cure (Rubber-sulphur mixing 90:10) :—

Sample No.	Time of Vulcanisation at 148°C	Tensile Strength.	Elongation at load of 1·04 kgs./sq. mm.
	(mins.)	(lb./sq. in.)	(per cent.)
1402	90	2050	831
1403	120	2000	795
1404	90	2230	749
1405	90	2300	795
1406	110	2480	729
1407	100	2440	720

All the samples have satisfactory tensile strengths except 1402 and 1403 which are definitely weaker than most samples of unsmoked sheet. Some of the samples are exceptional in that their maximum tensile strength is developed at a low elongation under a load of 1.04 kgs/sq. mm.

VULCANISATION AND AGEING TESTS.

The following are the results of vulcanising and artificial ageing tests.

Sample no.	Time of vulcanisation at 148°C.	Period of ageing at 70°C.	Tensile strength.	Elongation at load of 1·04 kgs./sq. mm.
	(mins.)	(hrs.)	(lbs/sq. in.)	(per cent.)
1402	80	nil	1580	852
		48	2310	777
		96	1820	733
		144	1380	700
1403	93	nil	1820	844
		48	2150	740
		96	1490	711
		144	220	—
1404	62	nil	1800	875
		48	2190	745
		96	1470	721
		144	370	—
1405	75	nil	1800	840
		48	2260	745
		96	1820	713
		144	270	—
1406	75	nil	1650	857
		48	2310	770
		96	1310	690
		144	280	—
1407	73	nil	1780	842
		48	2030	741
		96	1600	725
		144	270	—

Sample 1403, which is a hard rubber, vulcanised slowly, and sample 1404, which is a soft rubber, vulcanised quickly. The rate of vulcanisation of the remaining samples was similar to that of samples of unsmoked sheet previously examined.

All the samples gave satisfactory results in the artificial ageing tests. The maximum tensile strengths, however, are not quite so good as those usually obtained with sheet rubber.

CONCLUSIONS.

The following conclusions are drawn from these tests:—

1. The rubber from trees Nos. 400, 401, 439 and 445 is of satisfactory quality as regards plasticity, rate of vulcanisation and ageing.

2. The rubber from tree No. 24, which is suffering from *Ustulina* disease, is quick curing, judged by the usual standards. In other respects the rubber is normal.

3. The rubber from tree No. 2, from which a considerable amount of budwood is being obtained, is abnormal in several respects. The sample examined was somewhat harder than the others, had a long period of vulcanisation, and was rather weak.

No conclusions can be drawn from the experiments as to the suitability of the trees as "mother" trees. More information is needed concerning the relation between the quality of rubber yielded by "mother" trees and by established clones derived from them before arriving at a decision on this point. The limited work that has been done comparing the properties of rubber from "mother" trees and buds favours the view that the same abnormalities occur in both cases, but the investigations are not sufficiently extensive for definite conclusions (de Vries, *Archief. v. de Rubbercultuur* March 1924 p.127, de Vries, and Spoon, id., April 1927. p. 146).

Other difficulties arise in considering the bearing of the results of this investigation on the suitability of the trees as "mother" trees. For example, tree No. 24, which yielded the quickly vulcanising rubber, is suffering from *Ustulina* disease. This condition is abnormal and may be responsible for the quick rate of vulcanisation of the rubber. Tree No. 2, which yielded the hard, slowly vulcanising, weak rubber, has had half its branches pollarded for budwood. According to de Vries (Estate Rubber, p.467), this treatment would tend to produce weakness in the rubber.

Moreover, the variation in the appearance of the biscuits in each sample suggests that the method of preparation cannot be maintained uniform throughout the experiment. For example, some of the biscuits are very thin and some comparatively thick, and it is therefore possible that the amount of serum retained is irregular. Variations in the rate of drying had also occurred as some of the biscuits were distinctly wet on arrival in London.

Each of these factors has a considerable effect on vulcanising properties. A portion of each biscuit was included in the sample drawn for examination with a view to obtaining an average result, but the comparison of the samples would have been more satisfactory if the appearance and form of the individual biscuits had been less varied.

Imperial Institute,
London,
November, 1928.

BUDGRAFTING OF RUBBER

C. E. A. DIAS

[The following article was published by Mr. C. E. A. Dias in the local press. It is reproduced here at Mr. Dias' request and is followed by a reply to Mr. Dias' statements. *Ed. T. A.*]

IT is a great pity that budgrafting of rubber as a means of obtaining increased yields of rubber from the same area is not taken up as largely as it ought to be. This may be partly due to certain theories which have been put forward by our technical officers. At one time it was said that the age of the budwood and stock should be the same, or, in other words, the mother tree should be pollarded at the time the seed is planted for stock. I have completely proved the fallacy of this statement by getting budwood of ages from three months to couple of years old to take on to stock varying from nine months to eighteen years old.

After this, it was put forward that one must prove the stock before budgrafting is undertaken on a commercial scale. I cannot understand this at all. Our Department of Agriculture and the Rubber Research Scheme are unnecessarily delaying the work of pushing on with budgrafting to prove the mother trees until they are able to secure sufficient seed from stock of known trees, as they have a belief that the bud grafted on is influenced by the stock. In Ceylon, we have no pure line seed for stock in any case. The only seed we have in Ceylon is illegitimate seed as only the parentage of one side is known, and granted that the stock can influence the scion, with illegitimate seed one cannot expect the same influence.

I am now able to prove to a certain extent that the growth of the scion is not at all influenced by the stock, and the theory put forward by the Ceylon technical officers may not be correct. For the present, I am confining my attention only to the growth of the scion and not to the yield.

After the bud has taken on to the stock and starts growing, and from the time the stock is cut off at the union of the stock and scion, the stock begins to cease functioning, and very soon gets into a dormant state. As the bud or scion grows, it develops all round enveloping the stock, the tap root and laterals completely, and grows on its own, not only developing wood and bark over the union, but also enveloping the tap root and laterals. This new discovery was made by me a few days ago. I examined several sections of different ages. In every case it can be

The photograph mentioned in Mr. Diss' paper,

clearly seen that the stock attains a dormant state and is enveloped by the scion it has taken on. If this ocular demonstration is correct, and if the stock increases neither in girth, breadth, length, nor in any other manner, what influence can such a stock bear on its guest who has got hold of his little cottage and built a mansion all round it? It is not a case of the scion living on the stock and its root system. The idea that there is one plant above the union and another below it will have to be dispelled.

Have any of our technical officers ever examined a rubber union of stock and scion with a view to finding out what is taking place inside?

A longitudinal section of a budded rubber tree will prove all I say above.

I have not seen a section of this sort or a photograph of such a section anywhere before this, not even in the Netherland Indies where they have samples and photographs of everything imaginable with regard to rubber. I have photographed a longitudinal section of a budded rubber tree and hope to send you a copy in a few days for publication, as this would be the first photograph of this nature. If anyone interested cares to see these sections, they are at liberty to see and examine them either in my office in Colombo or at my laboratory on my Wawulugala Estate, Horana.

THE RELATIONSHIP BETWEEN STOCK AND SCION IN BUDDED PLANTS.

R. A. TAYLOR, B.Sc.,
PHYSIOLOGICAL BOTANIST, RUBBER RESEARCH SCHEME (CEYLON).

THERE has recently appeared in the local press a communication from Mr. C. E. A. Dias suggesting that the relationship believed to exist between stock and scion in budded rubber plants and their relative importance in the production of the final composite plant is not in accordance with the views previously held by botanists. In this communication it is stated that the scion is the only important member of the budded plant after union has been established and that the stock ceases to function after the bud has commenced its growth. It is further stated that the tissue produced by the growing scion envelops the stock in such a way as to completely enclose it and that afterwards the roots, stem and branches consist entirely of tissue derived from the scion. As these statements are open to doubt, it is considered necessary to give an explanation of what takes place after budding has been successfully carried out and the shoot has commenced its growth.

Development of budshoots.—In the early stages of its existence a bud is completely embedded in the cortex, has no connection with the wood of the stem, and can be seen as a small pimple when a bud patch is removed. When growth of the bud begins, tissue is produced both inwardly and outwardly. The budshoot gradually becomes attached by woody tissue to the wood of the stem and at the same time grows outwards to form a branch. The same process takes place no matter whether the bud develops on the stem on which it was originally produced or whether it has been transplanted to another plant, as in budding. When the top of a plant is cut off, one of the dormant buds beneath the cut develops and the shoot produced takes the place of the original stem. In the case of a budded plant care is taken that the transplanted bud only is allowed to shoot. The portion of the old stem remaining above the developing shoot then dies off. The tissue formed subsequently does not envelop any of the portion below the point of origin or attachment.

Proof of this can be obtained by sectioning in a longitudinal direction a sample of bark taken across the union of stock and scion in a budded plant. Such a section will show that in the symbiotic union produced in budded plants each of the symbionts retains its own characteristics. This is illustrated in fig. 1 which

is a semi-diagrammatic drawing of a longitudinal section of bark cut through the point of union. It will be seen that there are fewer stone cells in the stock portion than in the scion portion and that the other characters of the two cortices are quite different, each having retained its own special features. Fig. 2 shows photographs of longitudinal median sections through the top of a normal stump and it will be noted that they present exactly the same appearance as longitudinal sections through a stump which has been budded. The sections of fig. 2 should be compared with Mr. Dias' photograph of his sections.

The sharp line between the old and the new tissue of the stock is merely the result of the check to the growth of the stock when it was cut off (stumped). It is this sharp line that has given the impression that the tissue of the scion is enveloping the old stock. Actually the old and the new tissues of the stock are continuous; they are merely marked off from each other by the zone of smaller-celled tissue formed during the period between the removal of the stem of the stock and the development of the bud shoot. The same sharp line occurs in all rubber plants which have been cut off whether budding has taken place or not.

A similar phenomenon is that of the annual rings shown by deciduous trees in temperate climates. These are merely zones of small-celled tissue formed during the wintering periods and the enclosure of the old tissue by new tissue formed in the following season is exactly the same as the enclosure of the old tissue of the stock by the new tissue of the stock after it has been stumped. There is no question of the envelopment of the stock by the scion.

Importance of stocks.—In the present state of our knowledge of rubber it is not possible to make any reliable statements as to the influence of stock over scion but in view of the work which has been done on other plants it would be a mistake to neglect the possibility of such influence. In fruit crops where knowledge of budding or grafting has reached a much more advanced stage than in rubber it has been found that the nature of the stock has a very important influence on the resultant plant.

An abstract from a paper by R. G. Hatton entitled " The influence of different root stocks upon the vigour and productivity of the variety budded or grafted thereon" (Journal of Pom. and Hort. Sci., Vol. VI., No. 1, Feb. 1927), states: "These figures (given in the article) show that a single variety of apple budded upon four distinct varieties of root stock behaves very differently upon each, both in the amount of wood growth it makes and the fruit it produces. On one root stock it may make five times the wood growth that it does upon another; or again it may fruit ten times as heavily".....'"It is claimed that a much greater control has been established over the tree than heretofore, as a result of a more precise knowledge of the influence of root stocks." Again,

other experiments have shown than where "double working" has been employed the variety used as an intermediate stock has had a distinct influence on the vigour of the second scion. In vine cultivation in France the stock is varied according to the nature of the soil, and in citrus culture the stock has been shown to have an important influence on growth and fruiting.

There is, in fact, a considerable amount of information available on the subject of the influence of stock on scion which goes to show that while each retains its general characteristics there is a decided inter-effect between the two. Consequently no research work on budgrafting in rubber should be carried out without keeping in mind the possibility of such influence, and the statement that the Rubber Research Scheme may be wasting valuable time in an endeavour to study this problem is not justified.

The following extract from the progress report of the Experiment Station, Peradeniya, for September, October, 1928 is of interest in this respect and should be carefully noted. "In plot 174, planted with budded rubber in November 1927, it was noticed that some plants had made greatly superior growth to the majority. It was found that 30% of the better grown plants were growing on their own stocks, whereas only 17% of the total number of trees are growing on their own stocks. It was also noted that 43% of the well-grown trees growing on their own stocks were Heneratgoda No. 2 budded on Heneratgoda No. 2 stocks."

The statement that delays have taken place owing to a desire to select good stocks as well as good scions is erroneous, for stocks of known parentage on one side have always been available. It has not been necessary to use stocks of entirely unknown parentage in the work being done by the Research Scheme.

Finally, the statement that no scientist in the research stations of the East has ever sectioned a budded plant is inaccurate, for in the *Archief voor de Rubbercultuur* for 1922 there is an article on the subject by Dr. Visher containing complete diagrams. In 1922 and 1923 respectively two officers of the Rubber Research Scheme had, while in Java, the privilege of examining the original sections used in the writing of that article.

Fig. 1. Longitudinal tangential section of cortex taken across the union of stock and scion. S, scion; St. stock; s.c., stone cells; 1, the lip left after the breaking off of the flap of bark which is folded over the attached bud for the first week or two after budding.

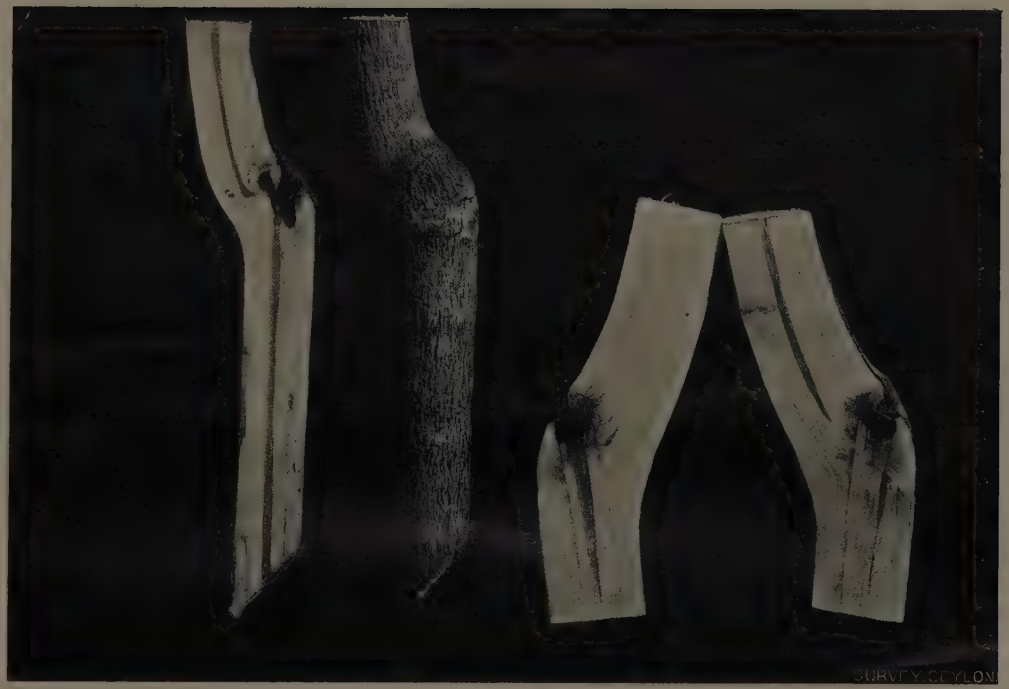

Fig. 2. Longitudinal sections through unbudded plants which have been stumped, showing the original stem and also the portion produced by the developing bud. Compare with similar section of budded plant.

SELECTED ARTICLES.

RUBBER PLANTING IN CEYLON.*

AS SEEN BY THE EDITOR OF "THE INDIA-RUBBER WORLD."

RUBBER TREES AND TAPPING AT CULLODEN.

AT the close of my first day at Culloden, when the sun had dropped low enough to make it fairly comfortable in the open, at Mr. Harrison's invitation we started out to see the rubber. The plantation is primarily for tea, the rubber having been planted later through the tea, and also in some of the valleys. The land is very rocky, iron-stone abounding, but there must be something in the soil that suits the *Hevea,* for it flourished wonderfully. The only place where it did not appear to do well was in very low ground, where there was no drainage.

The swampy portions of the land have, therefore, been thoroughly drained; indeed, where some of the seven and eight-year old rubber now is there had once been a bog where cattle were wont to get mired. The rubber on this soil, which was very rich, had some 3 feet of drainage. Of course it was to be expected that the *Hevea* would grow in such soil as this, but I must confess that I was amazed to see it flourishing far up on rock hillsides, and sending its laterals in all directions for food. The *Hevea* has proved itself, in Ceylon at least, a most voracious surface feeder, and in this connection it is worth while to examine the illustration of the uprooted tree held erect between two coconut palms, with the laterals stretched right and left, showing a growth longer than the tree trunk itself. The photograph, from which my illustration was made, was taken by Mr. J. B. Carruthers, and is most graphic.

NIGHT TAPPING.

The tapping of the trees begins just as soon as it is light in the morning, for through the middle of the day the *latex* does not flow freely, but starts up again about 4 in the afternoon and is continued until dark. The trees are tapped when they show a girth of 2 feet, without regard to their age. No ladders or supports are used in tapping, as it wasn't found profitable to tap higher than a cooly can reach while standing on the ground. The tool is a very simple V-shaped knife with two cutting edges, and a single slanting cut about 8 inches long has been found to be best, a tin cup being placed under the lower end of the cut and held in position by forcing its sharp edge under the bark. These cuts, by the way, are about a foot apart, sometimes closer and all run in the same direction, the herring bone and the V-shaped cuts being no more in evidence. The practice is also followed now of cutting a very thin shaving from one side of the cut, every other day, eleven times; in other words, re-opening instead of tapping. Before placing the tin cup under the cut, it is rinsed out in cold water to keep the *latex* from adhering to the tin, and also to keep it from

* An extract from *The Times of Ceylon* of August 2, 1904, kindly supplied by Mr. D. Davidson of Culloden Estate. It is published because of its historical interest.

too quick a coagulation. While I was there a very interesting experiment in scraping the outer bark from the trees had just been finished. The results, as far as could be determined, were such a stimulation to the lactiferous ducts that the flow was increased nearly 50 per cent. The oldest trees on this plantation, by the way, are 18 years, and have produced 3 pounds a year; by scraping the outer bark off they expect to get 6 pounds a year from each of these. There are only a few of these older trees, however, most of them being 7 or 8 years of age. All through the rubber orchards on this estate were hundreds of young Pará trees that were self sown; indeed in many places they had come up so thickly as to be a nuisance. The workmen on this estate, 100 in number, are all Tamil coolies, as the Sinhalese do not care to work, preferring to cultivate rice, a good crop of which insures them a two or three years' vacation. By the time we had examined a few Castilloa trees that were planted by way of experiment, night had fallen, and we wended our way back to the bungalow, where, after a hot bath, as is the custom of the country, we sat down to dinner in pajamas, the "punkah walla" stirring the heavy moist air by most vigorous pulls at the "punkah" cord throughout the meal. The rainfall up here in Kalutara is rather more than down at the coast, being, so I was informed, 144 inches, and the maximum temperature 94 degrees F. While I was there it was unusually dry, yet the rubber looked well and there was a record of six weeks without rain, which had no apparent effect upon it. The next morning we visited other parts of the plantation and saw a great deal of fine rubber. At present there is an excellent market for the seed, as so many new plantations are going in.

OIL FROM "HEVEA" NUTS.

As a better preparation, however, against the time when the seed will be a drug in the market, my host was experimenting with an oil made from the seeds. With a crude native mill he turned out an oil which the native women eagerly purchased to burn before their gods, while the pressed cake made an excellent food for cattle. During the forenoon I saw a large Ceará rubber tree cut down, and it seemed to have no *latex* in it at all. I also saw a Pará rubber tree, self sown, growing out of a cleft in the rock where there was apparently no soil, the trunk being 10 inches in diameter and apparently very thrifty.

RUBBER CURING HOUSE.

One of the most interesting features of this plantation was the rubber curing house, where the milk is coagulated and the rubber prepared for market. This is a one story brick building, 30 by 80 feet, smelling for all the world like a dairy as one steps within its doors. At one end of the room is a long table upon which are hundreds of enamelled iron pans capable of holding about a quart each. Into these pans the milk is poured through a cheese cloth strainer, after having been previously strained in the field. To it is often added a very little acetic acid—a *few* drops only. This is allowed to stand over night, and in the morning there is to be found in each pan a pure white pancake of rubber, soft, spongy, and full of water. Each cake is then rolled on a zinc covered table with a hand roller and much of the water thus expressed. The name of the estate is then stamped upon it with either a wooden or metal die, when it is ready for the heater room. The heaters used are simply charcoal ovens, the rubber being spread on wire screens above the fire, and left for three or four hours. By this time the pancakes have lost about 50 per cent. in weight and are beginning to assume a decidedly darker hue. Cakes in the condition described, if in South America, would be immediately marketed, but not in Ceylon. From the heaters they go to

drying racks, where they are air dried for a month to six weeks, depending somewhat upon the weather, and are shipped only after careful examination as to quality and dryness. The care which the planters are expending upon the preparation of the rubber is the best sort of guarantee that the quality will be sustained, and that the day will come when the name of a plantation on a cake of rubber will tell its value almost to a penny. To follow the rubber a little further it is, when perfectly satisfactory to the planter, packed in chests, the counter-part of the regulation tea chest, made of "momi" wood that comes in shooks from Japan, each package containing about 200 pounds.

COARSE RUBBER.

There is also a coarse rubber that is secured by picking the scrap from tapped trees. It is a very excellent rubber, and while I was there it found a market at 3s. 5½d., while the fine was bringing 4s. 9½d. There are those who claim that it is unwise to pick the film of rubber out of the tapping wounds in the tree, as there is danger that insects or disease enter there. Such a theory is plausible, but so far I have not heard of ill resulting from such removal of the air dried scrap.

TO REMOVE EXTRANEOUS MATTER.

This coarse rubber, by the way, was not absolutely clean; that is it contained bits of bark, and vegetable matter often-times. As labour is so cheap, and there is plenty of water, it could be very easily washed. For this purpose the ordinary corrugated roll washer that is used in the rubber factories has been suggested, but it hardly fits the case, as the scraps are so very small. A more practical plan would be to run them through a winnowing machine such as is used to blow the dirt out of peas and beans and let the air blast take out as much bark as possible. Then, if necessary, use a washer of the paper engine type to wash and beat the rest out. Of course, for quick drying the gum should then be sheeted, and either plain or corrugated rolls would accomplish that, and it could hang until dry. There is so little of the scrap, however, that the simple winnowing machine is probably all that would be necessary or profitable.

RUBBER STRIPS.

The time will come, however, when the coagulating and drying will have to be done on a different plan. The present method takes up too much room and is too slow. It would be perfectly easy to have coagulating pans that would deliver strips of rubber 10 feet long, a foot wide, and a quarter of an inch thick. These strips could then be run through rolls that would squeeze the excess water out, and, at the same time, imprint the plantation name every few inches. Then the strips could be hung up to dry and any degree of artificial heat applied that was thought best.

There have been suggested also a variety of quick coagulating devices, such as endless belts that take a film of milk into a drying chamber and deliver it to the other side coagulated and dried. Some such plan may prevail, but, as yet, the planters are not ready for it.

TIME BEST SUITED FOR TAPPING.

After many experiments the manager at Cullodon has satisfied himself that only the very early morning or the late afternoon are the proper times to tap, as in the middle of the day the flow of *latex* is almost nothing. The trees are therefore tapped from 4 until 7 a.m., and after 3-30 p.m. and as long as it is light. Indeed, the collection of the *latex* is often done by torchlight. As an instance of Mr. Harrison's alertness in getting all he can out of the trees with safety, he told me of a series of experiments that he was about to institute for all-night tapping. It seems he learned that

certain sugar estates did all their cutting of the cane by electric light, and that the amount of saccharine matter secured was much larger than in the day time, and, as the habit of the *Hevea* tree pointed toward more *latex* at night, he felt that a similar experiment would be justified.

RECORD OF YIELD.

At the present time he keeps a careful record of the production of each tree, and for this purpose the trees are numbered. When a tree has a circumference of 30 inches it is fit to tap, whether it is 5, 6, 7, or more years old. His first year's tapping in 1901 was 4,010 trees, from which he secured 4,600 pounds of first quality Pará. In 1902 the production was about the same, the production for 1903 from 8,300 trees being 10,500 pounds. From 2,500 trees on Heatherly, which has just come in bearing, he gets 3,500 pounds.

AN INTERESTING ANALYSIS.

To show how thoroughly Mr. Harrison is seeking for knowledge of the *Hevea,* he has even had the leaves analyzed to know just what they get in the way of food from the soil of Culloden. The analysis is as follows:—

	Fresh	Air Dried
Moisture	90·605 per cent.	10·600 per cent.
Organic matter	8·510 per cent.	85·150 per cent.
Ash	·849 per cent.	4·25 per cent.

The analysis of the organic matter showed that it contained 3·626 per cent. of nitrogen, while the ash showed as follows:—

	per cent.		per cent.
Phosphoric acid	·398	Lime	·084
Potash	1·320	Magnesia	2·117

Hence 1,000 pounds dried leaves would contain about 4 pounds phosphoric acid; 13·2 pounds potash; 8 pounds lime; 21·1 pounds magnesia; and 37 pounds nitrogen. From this it will be seen that the leaf is curiously rich in magnesia, but whether from selection or force of circumstances it is difficult to say.

HOW THE WORK IS DONE.

Most of the work is done by contract, each cooly being expected to get *latex* enough to produce one pound of dried rubber a day. It is very interesting to watch them as they troop up to the curing house early in the forenoon, with huge tin cans of *latex* on their heads, and to note how they watch the straining that none is slopped over, and even rinse cups, cans, and every receptacle and add it to the rest that no precious drop escape.

COST OF PARA RUBBER AT COLOMBO.

The rubber landed in Colombo costs 16 cents a pound, United States money. Just to let the sceptical do a little bit of thinking, and by the sceptical I mean the majority of rubber manufacturers who believe that the Pará from the Amazon is a better business proportion—just to start them thinking, therefore, I want to ask them to read the following:—

FINE PARA RUBBER FROM CEYLON.

Sells at Liverpool, per pound		$1·20
Cost f.o.b. Liverpool	·17	
Export duty	*nil*	·17
Planters' profit		$1·03

FINE PARA RUBBER FROM BRAZIL.

Sells at Liverpool, per pound		$1·00
Cost f.o.b. Liverpool, minimum	·21	
Export duty	·23	·44
Profit		$0·56

The above figures both for Ceylon and South America are very small—that is the cost figures. It is probable that 20 cents a pound for cost in Ceylon would be nearer actual practice, while Pará rubber costs landed in Para or Mañaos often 40, 50, and 60 cents a pound, the figures being dependent upon the section that it comes from.

As a matter of fact, the Tamil cooly whom the planters employ is not a high-salaried individual. His pay averages about 13 cents a day, United States money. To this is added the cooly "lines" or houses which are free of rent to him, as is also medical attendance. The planters keep no stores usually, but they do buy rice and furnish it at cost to their labourers, the allowance being 1 bushel a week for a man, and ¾ bushel for a woman.

CONCERNING SNAKES.

It was while sitting on the cool flags under the broad porch at the Harrison bungalow that the subject of snakes came up. Both my host and his friend acknowledged that cobras were very plentiful, and that they had a great liking for cool bungalows, which they sought to enter whenever they thought they could safely do so. They said it was a very rare thing, however, for a white man to be bitten by one. But the natives are often bitten, and sometimes fatally. The Sinhalese won't kill them, as they think the cobra quite likely to possess the soul of some dead relative of theirs. The Tamils, however, have no such prejudice and are perfectly willing to slaughter them whenever they can. My informants acknowledged that the bite of the cobra was very venomous, but not necessarily fatal. They said that, some years before, there had lived in that district a man who was known as the cobra king who not only cured snake bites in others, but was proof against poison himself. He used to tease the snakes to make them bite him, and even rub their venom into cuts on his arms, and apparently without the least injury. But he was finally attacked by a sort of rheumatism, which made him a helpless cripple, and he went back to England to get cured.

ARAPOLAKANDA ESTATE: SMOKING CEYLON RUBBER.

Close to Culloden is Arapolakanda, where I next visited, being entertained by the resident manager, Mr. H. V. Bagot. He has but fifteen acres of *Hevea* in bearing and gets twenty pounds a day. In coagulating, Mr. Bagot did not follow exactly the process used by his neighbour, Mr. Harrison, the difference being this: he added no acid to hasten coagulation, and also smoked the rubber over a fire of sawdust and bark. The final drying was accomplished by spreading on wire screens, and not a pound was shipped until it was perfectly dry and transparent. By the way, he reported that he had one "dumb" tree that was big, thrifty, and apparently exactly like the other, but that it gave no milk. At the lower end of Arapolakanda are some acres of marshly land that have been drained and reclaimed and on which is standing some fine rubber. As this land is near the river, it is sometimes innudated, the water standing four feet up on the trunks, but for a short time only. Mr. Bagot acknowledged that the trees were set back somewhat, but not very much. The general opinion in Ceylon, however, is that inundations are very apt to kill out the *Hevea.*

The oldest rubber on this plantation is some 15 to 18 years old, planted quite closely together in a sheltered nook. In this lot the outside trees which get the sun are by far the largest, one that I measured roughly being 2 feet in diameter and 60 feet high. After having seen all of the rubber, I examined the tea, saw what sights there were, and spent a very pleasant evening with Mr. Bagot, at whose bungalow I slept.

NAVIGATING THE KALUGANGA.

Very early the next morning, with a cooly carrying my luggage, I made my way to the river, and, climbing down its steep clayey bank, found myself aboard the steamer "Kaluganga." This craft was some 60 feet long and 12 feet wide, with a small wood-burning boiler and engine amidships. The forward deck was reserved for the whites, while the blacks huddled together at the stern. I had barely embarked, when down came one of Mr. Withers' coolies with two steamer chairs, one of which he had thoughtfully brought for me. After a most ear-splitting whistle, the little steamer cast off and started down the deep, muddy stream. Shortly after leaving the pier we passed the Clyde estate, which shows a large planting of tea and Pará rubber, the trees young, straight, and tall. The run down the river was a pleasant one, but in no way exciting, and, early in the forenoon, I took a train from Kalutara and was again back in Colombo.

AT COLOMBO: BOUND FOR SUNNYCROFT.

As I planned to leave for the Kelani Valley that afternoon, I went to the Grand Oriental Hotel for breakfast and a *siesta*, from which I was awakened by a pleasant young reporter, who interviewed me most thoroughly. I want to say in passing that all through the East the newspaper men seemed alive to the importance of the rubber question and printed many columns of things that I did and didn't say. When he had finished with me I summoned Miguel and we took rickshaws for Maradana Junction station and there bought tickets for Karawanella. After a somewhat tiresome ride in the train we reached our destination and I found Mr. W. Forysthe, of the Sunnycroft estate, awaiting me with a very swell rig consisting of a fine horse and high cart. Into the trap I got, and Miguel hiring a bullock hackery, we drove merrily off. The Forsythe conveyance soon left the other far behind, and as evening fell and it began to grow chilly, I was moved to ask how much further Sunnycroft might be. I then learned that it was eight miles from the station, whereas I had been told that it was two. As the road was constantly ascending, it grew colder and colder, and, as Miguel had my coat, I suggested to Mr. Forsythe that I was in for a chill. He, therefore, stopped at the bungalow of a planter friend and secured a coat for me, and our journey was then continued. Had it not been for the chill in the air, I should have enjoyed the ride mightily, as the road was most picturesque, winding through native villages, crossing rivers and often crowded with strange conveyances. Mr. Forsythe entertained me very pleasantly that night, and the next morning we walked some eight miles over his plantation. His land was exceedingly hilly, but under a high state of cultivation, showing many hundreds of acres of fine tea. He also had about three hundred *Hevea* trees planted in 1897, which would average 40 inches in circumference. In addition to this he had planted rubber everywhere through his tea, but very little of it was over 2 years old.

RUBBER IN CEYLON IN THE 'NINETIES.*

THE Editor has kindly asked me to contribute an article on the early history of the Rubber Plantation Industry. This is a more ambitious task than I care or feel competent to undertake. Instead will be ventured a few reminiscences of and reflections on the work carried out in Ceylon at the close of the last century, which culminated in the demonstration of wound-response and the introduction of the acetic acid method of coagulation.

Fresh from a botanical and chemical training at Cambridge, I accepted the temporary post of scientific assistant to the Director of the Botanic Gardens, Ceylon, a post which the then Director, Dr. J. C. Willis, had prevailed upon the Government to establish. This was the first step towards placing the Department on a wider scientific basis than formerly existed.

At first I believe the work suggested for me was the investigation of a fungal disease which was at that time attacking the stem of the cacao tree (*Theobroma cacao*). However, the planters saw their way to appoint a mycologist of their own, and the late Mr. J. B. Carruthers was chosen for the job, so I was free for other work.

Owing to the incoming of the motor car the problem of meeting in the near future the extra supply of rubber needed for its tyres was presenting itself; and so attention once more was being directed towards the possibility of cultivating caoutchouc-yielding trees at a profit. The foundation for such a cultivation in the Middle (Tropical) East had already been laid about twenty years previously by the introduction of such prominent American rubber trees as Ceara rubber (*Manihot Glaziovii*), Panama rubber (*Castilloa elastica*) and, most important, Para rubber (*Hevea brasiliensis*). The romance associated with the coming of the last-named tree to the East is a thrice-told tale and needs no repetition here; suffice it to say that the main of the plants raised at Kew from the seed collected by Wickham in Brazil went to Ceylon, and a branch garden at Heneratgoda in the low-country was formed for their reception. This grove and especially the high-yielding tree known as Number 2 have become historically famous.

Dr. Willis, fully alive to the necessity of investigating rubber trees from the standpoint of a remunerative cultivation for Ceylon, appointed me to this work. The British planting community there had already made a trial of Ceara rubber, a small tree capable of flourishing at higher elevations and in drier situations than *Hevea*. At the time of the coffee disaster it was a tree capable of being tried on the abandoned plantations, and was one of the cultivations attempted between the downfall of coffee and the rise of tea. In 1883 nearly a thousand acres were reported to be under Ceara, but its cultivation was not a financial success, the general opinion being that it paid to collect the rubber, but not to cultivate the tree. When I arrived in Ceylon (1898) as far as I know there were no longer any planted areas of Ceara of importance, though the tree was very evident as an escape, and naturally specimens were growing in the Botanic Gardens, upon which a certain amount of experimental work was done.

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* A record of early experimentation by Dr. Parkin in *The India Rubber Journal*. Vol. LXXVI, No. 18, October, 1928.

The Ceylon planters having failed with Ceara were now a trifle shy about taking up rubber cultivation again, but Dr. Willis, concentrating on *Hevea brasiliensis,* gradually focussed their attention on this untried tree as one suitable for growing in the moist low country. At that time no one could definitely assert that its cultivation would be a success.

A FALSE TRAIL AVOIDED.

Just before my time in Ceylon Mr. Biffen (now Sir Roland Biffen of wheat fame) went as scientific adviser on a short expedition to tropical America to study rubber trees and came back imbued with the idea that *Castilloa* and not *Hevea* was the tree to cultivate. The latex, he found, flowed freely from the former and much could be collected from a single tapping; and further, the caoutchouc could be readily separated from it by centrifugal means. *Hevea,* on the other hand, gave a poor yield and its milk could not readily be dealt with in this way. The future, however, has shown that those who put their trust in *Castilloa* backed the wrong tree. It was largely planted (or supposed to be) in Mexico and Central America, and many companies floated. But one might ask where are those companies now?

Biffen's opinion naturally influenced me considerably at the beginning of my period in Ceylon. I confirmed his statement about the latex flowing freely from *Castilloa,* and tardily and thickly from *Hevea.* Also experiments were made with a cream separator at the Agricultural School in Colombo with the kind permission of the Manager, Mr. Drieberg. The latex of *Castilloa,* we found, centrifugalised readily (in fact it creams on standing), whereas that of *Hevea* at the speed attainable failed to separate. Still *Hevea* seemed the tree upon which to concentrate partly because it yielded the best wild rubber and partly because it was the one rubber tree which in the mature state existed in any abundance in the Island, thanks to the original grove planted at Heneratgoda and its offspring. At that time centrifugal rubber seemed the ideal, *i.e.,* the separation of the caoutchouc from the latex in comparative purity. We did not then know that certain constituents of the serum were of value in speeding up vulcanization. Now that artificial organic accelerators are obtainable and can be added, this objection to pure caoutchouc loses some of its weight.

Apropos of centrifugal rubber, I had in 1910 (the boom year) an interesting experience with a syndicate that was out to float a company for the purpose of applying the principle of the cream separator to the preparation of raw rubber in the Middle East. An article from my pen on the Plantation Rubber Industry had just appeared in *Science Progress,* and in the section devoted to centrifugalisation doubt had been cast on the feasibility of preparing Para rubber in this way. The syndicate had read this, and being perturbed by it wrote to me for an interview. This was granted and took place at Cambridge. Biffen was also drawn into it. The American member of the party, I remember, brought a pleasing sample of *Castilloa* rubber prepared by their centrifugal machine. They wanted my name on the prospectus, but I said I could not honestly lend it unless I had ocular proof that their machine could separate *Hevea* latex; and even if it could I doubted very much whether it would remove the rubber particles so completely as is done by the acetic acid method of coagulation. Having some ammonia-preserved latex by me I demonstrated the process to them, showing how a perfectly clear serum was left after coagulation. I fancy this company never was floated.

To return to the old Ceylon days, seeing that centrifugalisation was apparently not practicable with *Hevea* latex and feeling that the crude method of preparing samples of raw rubber at Heneratgoda must be capable

of much improvement, I set about to find how the latex could be coagulated. Ceara latex clots on heating, but not so that of *Hevea*. A trace of acid, however, brings about coagulation no matter what the dilution. Various acids (as well as a number of salts) were tried to see which could be recommended. Peradeniya in those days had for a laboratory merely a small room adjacent to the director's office, and the appliances and reagents in it were of a meagre character. Perhaps that is why formic acid was never tried by me. I had through my hands the usual mineral acids and the commoner organic ones, such as acetic, oxalic, tartaric and citric. Acetic acid was finally chosen and recommended as the most satisfactory coagulating agent. For one reason it is a weak acid with little corrosive power and for another it has a wide range of applicability. If too much acid be added to *Hevea* latex coagulation ceases to be complete and with a strong acid like sulphuric the range is very narrow, a little in excess and the serum becomes milky. Acetic acid, on the other hand, can be added in considerable excess before milkiness appears in the serum. The amount of acetic acid recommended for a given volume of *Hevea* latex turned out to be much greater than necessary, a fortunate circumstance on account of expense. I recollect I was a little troubled at the amount required. The discrepancy between laboratory experiment and later estate practice has been explained through the spontaneous increase in acidity of the latex on standing. My experiments were done with latex drawn straight from the tree. If it had been allowed to stand a few hours less acid would have been needed. Latex on estates is collected some time before it is coagulated. It should also be borne in mind that for my experiments latex from first tapping was used. We had not then begun to take advantage of wound response.

Formic acid, which chemically is in the same series as acetic, was shown later to be an efficient coagulator. Recently on the score of expense, as it is now cheaper than acetic, it is being used to some extent instead, especially in Java; but its greater corrosive action on the rolling mills may outweigh its lower cost.

It is perhaps a little surprising that the acetic acid method has lasted so long and still persists. Since fine Para made by the native method of the Amazon is superior (or we are led to believe so) to plantation rubber, one imagines a product containing all the ingredients of the latex save water would be the ideal. The spraying method achieves this. Is it making headway or is the extra cost of installation the chief handicap in its extension?

EARLY WOUND RESPONSE INVESTIGATIONS.

It was while conducting laboratory experiments on coagulation that I first became aware of the great influence wounding had on the flow of latex. For these experiments latex was collected in test tubes from the few adult trees growing at Peradeniya. As a rule each collection was made from cuts in virgin (*i.e.*, previously untapped) bark, thinking at that time that more latex could be got in this way and also that the samples would be more uniform than from areas of bark which had recently been tapped. Happening on one occasion to make an incision near one made a day or two before I was surprised at the abundant flow of latex from it. This set me experimenting, with the result that the stimulus wounding gave to the flow of latex was amply demonstrated. Instead of tapping *Hevea* trees at fairly long intervals, as was then thought to be advisable, regular tapping every other day was seen to be practicable and in fact to be advocated. Dr. Willis had found previously from the tapping results at Henerategoda that at weekly intervals the second tapping gave twice as much rubber as the first. The explanation of this was evident now.

From recent literature on the early history of rubber planting it seems that Singapore was aware of this peculiarity shown by Para rubber trees, as the authorities there had had over from Brazil native tappers who spoke of the first tapping as merely *calling the rubber.* We in Ceylon, working, as it were, in a watertight compartment, rediscovered the need of *calling the rubber,* which doubtless had been known for ages in the basin of the Amazon. David Fairchild, in a recent article on *The Beginning of the Rubber Industry,* asks who introduced the term wound-response, stating that it does not occur in the Ceylon Circular of 1899. He is right in this, for on referring to it I do not find the expression, but instead, wound-effect and wound-reaction. In a paper on *Latex and its Function* I wrote the following year for *The Annals of Botany* "wound-response" occurs twice, and in my *Science Progress* article it is used as a heading, so it looks as if the responsibility falls upon me.

Among rubber trees *Hevea brasiliensis* appears exceptional in so increasing its flow of latex through the stimulus of wounding. Amongst the many latex-yielding trees, besides the actual caoutchouc ones, surely there must be some that would show this phenomenon; but no botanist, as far as I am aware, has demonstrated this as yet.

With the recognition of wound-response the budding industry of rubber planting looked decidedly more promising. The quantity of rubber obtained from the initial tapping was shown to be little guide as to the amount the tree was capable of yielding in a year. A few tappings per annum could no longer be thought the practice. The tree revealed itself as one capable of being treated like a cow and milked regularly; and the factory like a dairy with raw rubber in place of butter and cheeses as its output. With the introduction of regular milking conservation of bark became imperative, and so the reopening of the wound instead of fresh cuts, excision in place of incision, became the rule. In the initiation of this practice I had no share. My time was up. Taking advantage of wound-response and the acetic acid method of coagulation, Ceylon produced the biscuit, the first form in which plantation rubber was exported, to be later superseded by crepe and sheet. Over a quarter of a century has elapsed since these early experiments when *Hevea* trees in the East existed in their tens and now in their millions, yet the memories of those days are so vivid that they seem but as those of yesterday.

MANURING OF PADDY IN LOWER BURMA.*

ON the 9½ million acres of swamp paddy land in Lower Burma where almost the whole of the Burma rice of commerce is produced, the paddy crop has hitherto been grown practically without manure. There is an impression abroad that this land receives an annual coating of river silt which enriches the soil and maintains its fertility. But, so far as the main paddy is concerned, this is not so; and the land which does receive this coating of silt, with the exception of some parts of the lower Delta, is generally in such a precarious position, liable to severe damage by floods, that paddy growing there is a very speculative business and may be left out of consideration in the present paper entirely. The main part of the paddy area receives no annual coating of silt, but is on such a level that, while by means of small field embankments it can hold enough rain water to mature a crop with a growing period of 150 to 200 days, it is high enough to be comparatively safe from the flood waters of the Burma rivers during the monsoon.

The comparatively high prices ruling for paddy since the war have encouraged the extension of cultivation into the low-lying and more precarious tracts which do receive silt, and it is chiefly owing to this fact that so much has been heard in the past few years of the increasing damage done by floods to the paddy crop; for these low-lying areas on the margin of cultivation, and more or less recently brought under the plough, have suffered most.

PERMANENT LEVEL OF FERTILITY REACHED.

The system followed, of continuous annual cropping with paddy, is exhausting when practically nothing in the way of manure is returned to the soil; but most of the land has already lost its virgin fertility and has been reduced to a level of productiveness which now appears to be fairly constant, a level at which the plant food removed by the annual rice crop is made good by the natural breakdown of the soil. The only reliable statistics available do not show that there has been any progressive decline in fertility within recent times; and this is supported by settlement and other reports going back farther than 1913-14, from which year comparable records of acreage yields are available. Taking the Hanthawaddy district settlement reports as an example, the reports from 1872 to 1910 show that, in the areas dealt with, there has been no decline in fertility during this time. The actual figures given show yields per acre well above the average now accepted for the country as a whole, and we are probably safe therefore in assuming that under the present system of cultivation a general average yield of about 1,500 lb. per acre, apart from annual fluctuations, may be expected to continue in Lower Burma for some considerable time.

Under the circumstances, this yield may be considered fairly good and compares not unfavourably with that of some other tropical rice-growing countries. The following table compiled from figures extracted from the International Year Book of Agricultural Statistics shows the relation between the principal rice-growing countries in 1926. The figures must be regarded as a rough indication only, since methods of recording yields vary in different

* By David Hendry, M.C., B.Sc., N.D.A., Deputy Director of Agriculture, Southern Circle, Burma, in *The Agricultural Journal of India*, Vol. XXIII, Part V, September 1928.

countries, and China, one of the largest rice-growing countries, records no figures at all. Thus, as an example, the acreage yield in India as a whole is based on the sown area, while that for Burma is on the matured area only.

Principal rice-growing countries.

Country	Acreage of rice	Yield per acre
		lb.
India	79,134,000	1,281
China	...	...
Indo-China	12,795,000	1,041
Java	8,356,000	1,378
Japan	7,738,000	2,875
Siam	7,157,000	1,680
Philippines	4,252,000	1,014
Korea	3,885,000	1,565
French Guinea	2,038,000	890
Formosa	1,400,000	1,761
Madagascar	1,372,000	960
Brazil	1,323,000	1,130
U.S. America	1,014,000	2,252
Ceylon	829,000	676
British Malaya	664,000	1,006
*Soviet Russia	583,000	1,050
Sierra Leone	400,000	1,503
Italy	365,000	4,062
Egypt	191,200	2,847
Senegal	123,300	890
Spain	121,000	5,800
Mexico	118,400	1,360

* Pre-War—1909-1913.

The yields in Spain, Italy and Japan are outstanding, and have been so for many years, due to the intensive methods adopted there; but it is worth while noting that until 1916 the yield in America was approximately the same as for Burma, and the higher figure now shown is a comparatively recent achievement. This increased yield has been brought about principally by the more extended use of fertilisers; and, although a similar increase could be brought about in Burma by the same means, this could not in the past be done at a profit for reasons which will be adduced later.

NEED FOR MANURING.

The need for manuring of paddy land in Lower Burma has been one of the subjects under investigation at the Hmawbi Experimental Station for a number of years, and among other experiments a series of plots treated with different manures was laid down in 1913 designed to ascertain what manurial constituents were deficient in these soils and to what manurial treatment they would probably respond best. This experiment was continued for ten years, the individual plots being manured as shown below for five consecutive years, and the controls left untreated. Manuring was then discontinued and all plots were observed for a further period of five years to record the residual effect of the different manures employed. The results have been published in the annual reports of the Hmawbi Station, but I have condensed them here into a single table which is given below.

No. (a)	Treatment (per acre) (b)	Five years' manure. Per cent increase over average of controls (c)	Five years' residual effect. Per cent increase over average of controls (d)
1	Cattle manure at 30 lb. nitrogen	+37·5	+21·8
2	Cattle manure at 50 lb. nitrogen	+52·3	+34·5
3	Cattle manure at 70 lb. nitrogen	+68·7	+37·8
4	Cotton cake at 50 lb. nitrogen	+54·8	+29·2
5	Cattle manure at 30 lb. nitrogen, superphosphate at 30 lb. P_2O_5 sulphate of potash at 30 lb. K_2O.	+53·0	+54·0
6	Cattle manure at 30 lb. nitrogen, superphosphate at 20 lb. P_2O_5.	+43·5	+27·6
7	Cattle manure at 30 lb. nitrogen, bone-meal at 20 lb. P_2O_5.	+51·0	+31·8
8	Bone-meal at 20 lb. P_2O_5.	+26·5	+ 9·5
9	Superphosphate at 20 lb. P_2O^5.	+35·3	+15·3
10	Sulphate of potash at 20 lb. K_2O.	+ 5·0	+ 6·6
11	Sodium nitrate at 30 lb. nitrogen	+17·0	+35·5
12	Sodium nitrate at 30 lb. nitrogen (Applied as to dressing).	+ 5·0	+25·0
13	Nitrolim at 30 lb. nitrogen	+11·0	+64·2
14	Ammonium sulphate at 30 lb. nitrogen	+32·5	+25·5
15	Lime at 2,000 lb.	+24·0	+ 1·9
16	Ammonium sulphate at 30 lb. nitrogen, superphosphate at 20 lb. P_2O_5, sulphate of potash at 20 lb. K_2O.	+33·5	+17·5

Among other information provided by this table, the most important facts are the indications given that the chief requirements of paddy on these soils are nitrogen in the form of ammonia and phosphate; that potash is not shown to be a definite limiting factor; and that nitrogen in the form of nitrate is distinctly harmful. The deficiency in nitrogen and phosphate shown is confirmed by the chemical analyses of these which are also published in the station reports, and subsequent experiments have borne out the correctness of the conclusions drawn. The Lower Burma soils differ from the Upper Burma soils in being distinctly acid, and respond to dressings of lime although in no very great degree; and experiments with lime have shown that while it is beneficial to the soil and increases the crop, the cost renders its use uneconomic.

INDIGENOUS MANURES AVAILABLE.

The more or less readily obtainable indigenous manures able to supply the deficiencies indicated include cattle dung, bats' guano, fish waste, bone-meal, rice bran, cotton cake, green manure crops, etc.; but the quantities of each are quite inadequate for the purpose of bringing about any marked increase in fertility. Cattle dung is by far the most important and the quality and amount of this available for paddy land may well be considered first.

In the system of cultivation followed, one pair of bullocks is able to work from 8 to 12 acres, and, as there is practically no land other than paddy land worked by bullocks, an average of one pair of bullocks to every 10 acres is a reasonable figure to assume for the ratio of livestock to cultivated area. Cattle are only bred locally to a negligible extent owing to the unsuitable

swampy conditions, and nearly all the working bullocks are imported from the dry zone of Upper Burma. This being so, the cultivator seldom keeps more bullocks than are strictly necessary to cultivate his land, and he has no young stock to augment his supply of cattle dung. Other cattle there are kept on the uplands by Indian cow-keepers for milk purposes, but these contribute practically no manure to the paddy land. The ratio of one pair of bullocks to 10 acres of land is borne out by the figures of livestock and the cultivated area for the two great paddy-growing divisions in Lower Burma. The Pegu and Irawaddy divisions comprise between them 7,342,174 acres of cultivated land including gardens, which constitute only about six per cent. of the whole; the livestock, comprising bulls, bullocks, cows and young stock, and including all classes of buffaloes, amounts to 1,490,134 animals, or 745,067 pairs, which is near enough 1 : 10 for our purpose.

The amount of dung which a single bullock will contribute to the manure pit in the course of a year, according to records kept at the Hmawbi Station, is about three tons, or approximately six tons per pair. If carefully conserved, this amount would be available each year for 10 acres of paddy land; but under village conditions the need for careful conservation is not appreciated, and the wastage is so great that not more than half this quantity ultimately finds its way to the land. In fact so little is the value of cattle dung appreciated in some of the more fertile tracts that I have seen a cultivator throw it into a near-by creek to avoid the trouble of storing and carting it on to his land.

The more ordinary way of using the available cattle manure is to collect what has been loosely stored in the open for the past year and spread it on the nurseries which constitute a tenth of the holding; the main area is not manured at all. The manure so applied, in addition to being deficient in quantity, is lacking in quality; concentrates are only fed to the cattle on a small scale, and when the manure has been stored in the open through part of the rains it is very poor stuff indeed, as analyses show.

There is a good deal of scope for improvement in the methods of conserving and applying this best of all manures, and efforts towards bringing this about are being made by the Agricultural Department; but, even when the best has been done, the fact remains that there is not enough cattle manure to go round, and a dressing which at best averages about three tons for 10 acres can hardly be considered sufficient to maintain the fertility of the land, far less to improve it.

Of the other manures such as bats' guano, fish waste, bone-meal, rice bran, cotton cake, etc., these are either strictly limited in quantity like the first three, or fetch higher prices for other uses outside general agriculture than they are worth as manure. Even the purely manurial substances like bats' guano and fish guano sell for much higher prices to gardeners and concerns growing valuable money crops than a crop of low money value per acre like paddy can afford to pay. The use of these expensive manures on paddy although it increases the outturn per acre considerably results in a heavy monetary loss, as experiments at the Hmawbi Station clearly show. Bone-meal is on the border line and just manages to pay its way.

The growing of green manure crops constitutes a well-recognised method of maintaining and improving soil fertility, but on the old paddy land these cannot be grown with any reasonable prospect of success. When the rains finish in early November, the soil dries up very quickly and assumes a cement-like hardness in which no green crops will grow; even seeds broadcasted among the ripening paddy crop fail to establish themselves. Most of the known green manure crops and the different methods of growing them have been tried under these conditions, but have failed. The hard condition of

the ground associated with the long rainless spell from November till May renders growth difficult, but on some of the retentive soils of the middle zone to the north of the main paddy area I have seen a green crop of sunn hemp grow very well indeed.

These are the main sources of indigenous manure. Night soil is not included, for the people of the country will not touch it; and the attainment of a high standard of permanent and increasing fertility by this means, similar to that existing in China and Japan and described in King's *Farmers of Forty Centuries,* appears to be outside the bounds of possibility.

Synthetic farm-yard manure appeared an attractive proposition for Burma, but it is expensive to make, and experiments with it at Hmawbi since 1923 have been disappointing so far as profits are concerned. The prospect of its use has not been abandoned, however, and experiments with this form of manure are being continued.

ARTIFICIAL FERTILISERS.

This brings us to the use of imported fertilisers to augment the scanty supplies of indigenous organic manures, and the reasons why these have not been more strongly advocated for paddy in the past.

To supply the important constituents of ammoniacal nitrogen and phosphoric acid, the manures available hitherto have been sulphate of ammonia and superphosphate, and these have proved entirely suitable for the swampy conditions under which paddy is grown. But it has already been mentioned that a crop of low money value per acre like paddy cannot give an economic return for expensive manures. As I shall show later, imported sulphate of ammonia and superphosphate are cheaper than the indigenous manures already dealt with, and the question of whether it was economic or not to use these manures has depended upon the relative prices of the manure and the paddy, both of which have fluctuated considerably in the past.

The prices of sulphate of ammonia and superphosphate at Rangoon before the war, and at the present time, are as follows:

Year	Sulphate of ammonia per ton	Superphosphate (18-20) per ton
	Rs.	Rs.
1914	240	75
1919	488	150
1928	170	75

For ten years before the war, the threshing floor price of paddy in the districts close to Rangoon fluctuated from Rs. 96 per 100 baskets (approximately 5,000 lb.) to Rs. 152 per 100 baskets. The price in 1914 was Rs. 125, and the average for the ten years' period prior to the war was Rs. 124. Since 1920 the price has fluctuated between Rs. 145 and Rs. 196 with an average of Rs. 176. In the present year the threshing floor price was Rs. 170, but, contrary to custom, has fallen since to Rs. 160 at the beginning of the rains.

Taking the general average crop as 1,500 lb., or 30 baskets per acre, an application of 1 cwt. of sulphate of ammonia plus 1 cwt. of superphosphate per acre can be expected to increase the crop by approximately 30 per cent. The actual increase to be expected varies with soil and other

conditions, but that this figure is not an over-estimate will be shown by the results of a recent experiment to be quoted later.

Taking the situation as it was in 1914, let us see what the monetary results of such an application to such a crop would have been.

Adding Rs. 10 per ton to the cost of sulphate of ammonia and to that of superphosphate to get the manure from Rangoon on to the cultivator's holding, 1 cwt. of the former would cost Rs. 12-8 and of the latter Rs. 4-4, a total of Rs. 16-12. A thirty basket crop at Rs. 125 per hundred baskets would be worth Rs. 37-8. An increase of 30 per cent. on this would be Rs. 11-4; and the difference between Rs. 16-12, the cost of the manure, and Rs. 11-4, the resulting increase in the crop, would be a loss of Rs. 5-8 per acre.

In 1928 the corresponding figure would be: cost of manure Rs. 13-4; value of crop Rs. 51; value of 30 per cent. increase, Rs. 15-5; result, gain of Rs. 2-1 per acre.

These figures are shown more concisely in the following form :—

	Paddy price per 100 baskets	Value of crop of 30 baskets per acre	Value of 30 per cent. increase	Cost of manure per acre	Difference
	Rs.	Rs.	Rs.	Rs.	Rs.
1914	125	37 ·5	11 ·25	16 ·75	Loss 5 ·50
1928	170	51 ·0	15 ·30	13 ·25	Gain 2 ·05

NEW ARTIFICIAL FERTILISERS.

This shows clearly the change which has been brought about since before the war, partly by the drop in the price of artificial manures and partly by the rise in the price of paddy. But a circumstance has arisen which is of greater importance. This is the advent of the new manures combining ammoniacal nitrogen and phosphate in one, produced at a cheap rate by methods evolved as a result of the work done on high explosives during the war. Two of these are available now in India and one of them has been tried over the past three years on paddy land at Hmawbi and in the surrounding districts. With another now under trial, calculating the cost per acre on exactly the same basis as in the previous table, the cost of the same quantities of nitrogen and phosphate to produce the same effect would be Rs. 11-2 instead of Rs. 13-4, and the price of paddy would have to fall below Rs. 124 per hundred baskets before the balance of profit and loss was tipped in the wrong direction. These new manures also possess the added advantage of being single chemical compounds which require no mixing; and, owing to their concentration, the transportation charges are cut in half.

EXPERIMENTAL RESULTS.

The first of these new manures to come to hand for trial in 1924 was Ammo-Phos which was obtained from New York in two grades, 20-20, and 13-48. This gave promising results, and an experiment was put down last year to determine the optimum dressing per acre. The quantities used were 50, 100, 200, and 300 lb. per acre, and the plots for each were laid out in a continuous series, each treatment being replicated six times. The size of

each individual plot was approximately 1/41 of an acre. The response to the manure was remarkable, and, although the season was a good one and the appearance of the plots during the growing season bore out the final weighing results the uercentage increases of from 47·7 per cent. to 118·6 per cent. are higher than can be normally expected. Taking the cost per ton of Ammo-Phos plus freight at Rs. 230 for the 20-20 grade, and Rs. 255 for the 13-48 grade, paddy at Rs. 170 per 5,000 lb. and allowing nothing at all for the increased straw which has no value in Burma, the results of the experiments with the 20-20 grade and 13-48 respectively were as follows :—

Ammo-Phos. 20/20 grade. Fields Nos. 75 and 76. Size of plots—0·024 acre. Variety of paddy—C19-26. Replicated six times : 32 plots.

No.	Nature of treatment per acre 1	Yield per acre		Increase per acre		Value of increase per acre 6	Cost of treatment per acre 7	Profit per acre due to manure 8	Per cent. increase in grain per acre 9
		Grain 2	Straw 3	Grain 4	Straw 5				
		lb.	lb.	lb.	lb.	Rs. A.	Rs. A.	Rs. A.	
1	Control	1,250	3,292	—	—	—	—	—	—
2	50 lb.	1,846	4,158	596	866	20 4	5 2	15 2	47·7
3	100 lb.	2,096	5,267	846	1,975	28 12	10 4	18 8	67·7
4	200 lb.	2,542	6,504	1,292	3,212	43 15	20 8	23 7	103·4
5	300 lb.	2,733	7,250	1,483	3,958	50 7	30 12	19 11	118·6

Standard error..... 4·6 per cent.

Ammo-Phos. 13/48 grade. Fields Nos. 51 and 52. Size of plots—0·024 per acre. Variety of paddy—C19-26. Replicated six times : 32 plots.

No	Nature of treatment per acre 1	Yield per acre		Increase per acre		Value of increase per acre 6	Cost of treatment per acre 7	Profit per acre due to manure 8	Per cent increase in grain per acre 9
		Grain 2	Straw 3	Grain 4	Straw 5				
		lb.	lb.	lb.	lb.	Rs. A.	Rs. A.	Rs. A.	
1	Control	1,533	3,846	—	—	—	—	—	—
2	50 lb.	1,971	4,358	438	512	14 14	5 11	9 3	28·6
3	100 lb.	2,017	5,200	484	1,356	16 7	11 6	5 1	31·9
4	200 lb.	2,575	6,071	1,042	2,225	35 8	22 12	12 12	67·9
5	300 lb.	2,650	5,659	1,117	1,813	38 0	34 2	3 14	72·9

Standard error.....3·7 per cent.

These are exceedingly promising results and raise several points of interest which there is no space to discuss here; but one thing is made clear, and that is that profitable manuring of paddy with artificial fertilisers available in quantity is now within the scope of possibility. After discounting the admittedly high increases, which are nevertheless given as they are weighed out, it must be remembered that the profits shown are for one year only, and previous experiments at Hmawbi have shown that the effect of this

manure lasts for two years, the increase in the second year being from one-third to two-thirds those in the year of application. The second year, or residual effect of the 13-48 grade is higher than that of the 20-20 grade, which is to be expected from the higher phosphate content of the former; but the quick returns obtained with the 20-20 grade in the first year are all important where money for expenditure on manures of this sort may have to be borrowed at excessively high rates of interest. Incidentally, interest charges have not been included in the above tables, but the profits shown allow for a fair addition of this kind.

In both cases the optimum rate of application is 200 lb. so far as profit per acre is concerned, but the outlay involved in such a dressing is hardly likely to commend itself to such landowners and cultivators who may be induced to take up these manures for some time to come. Application of 50 and 100 lb. are quite satisfactory, however, and these should be good enough to begin with. The time of application is important. The best time is when the fields have been more or less drained off before transplanting; applied later when the fields are full of water the manure is wasted.

NITROGEN-PHOSPHORIC ACID RATIO.

Before leaving these two grades of manure, I am tempted to quote another Hmawbi experiment showing the optimum ratio of nitrogen to phosphoric acid for the paddy soils being dealt with. The experiment was a pot experiment and the results obtained indicate that the best ratio lies somewhere between 1 : 1 and 1 : 3 of $N : P_2O_5$ with a strong assumption that it is about 1 : 2.

Optimum nitrogen-P_2O_5 ratio. Variety of paddy C15-10. Replicated ten times: 60 plots.

No.	Treatment N: P_2O_5 ratio	Tillering	Outturn			Grain straw weight ratio	Remarks
			Grain	Chaff	Straw		
1	2	3	4	5	6	7	8
			gm.	gm.	gm.		
1	Control	8·6	29-58	0-98	45-47	1:1·54	
2	1 : ½	10·0	25-23	1-31	55-50	1:2:20	
3	1:1	9·5	30-17	1-00	52-10	1:1·69	Standard error 1·6 or 5·3 per cent.
4	1:2	8·6	34-68	0-45	50-90	1:1·47	
5	1:3	8·7	32-69	0-63	56-87	1:1·73	
6	1:4	9·2	28-53	0:75	58-98	1:2·07	

These figures, though fairly regular and indicative of whereabout the ratio lies, are not accepted as final, and the experiment is being repeated this year on a field scale. Another experiment on a field scale showing the ineffectiveness of potash when added to nitrogen and phosphate manures on these soils might be quoted, but the full experiment will be found in the printed report of the Hmawbi Station, and it will suffice here to say that at present this manure does not pay its way.

COMPARATIVE COSTS OF COMMON MANURES.

While on the subject of these manures and their relative costs, it is of interest to note the unit values of those which have been referred to in this paper, and, taking present prices, I have tabulated these below. With the exception of the slow acting bone-meal it will be seen that indigenous

manures are dearer per manurial unit than the new artificial fertilisers. Of course, organic manures have an additional value of their own, but here they are limited in quantity, and any increase in demand is followed by sharp rises in price as has been noticed in the case of bats' guano.

No.	MANURE	Place	Price per ton Rs.	Analyses			Unit values in Rs.		
				N	P_2O_5	K 0	N	P_2O_5	K_2O
1	Ammonium sulphate	Rangoon	170	20·6	...	...	8·25	...	...
2	Superphosphate 18—20	do	75	...	19	...	...	4	...
3	Sulphate of potash	do	205	...	...	50	...	...	4·1
4	Ammo-Phos 20—20	do	220	16·48	20	...	8·42	4·08	...
5	Ammo-Phos 13—48	do	245	10·70	48	...	7·21	3·50	...
6	Bats' guano	Kyaukse	55	5·03	1·86	0·83	8·67	4·20	4·31
7	Bone-meal	Rangoon	85	2·04	32·78	...	4·82	2·34	...
8	Fish manure	do	150	7·71	2·95	0·65	15·8	7.7	7·88
9	Cotton seed meal	do	82·5	5·90	2·70	1·45	10·40	5·10	5·3
10	Cotton seed cake	do	88·4	6·71	2·34	1·33	10·2	4·95	5·15
11	Diommonphos 20—53	do	307	20·60	52·50	...	6·66	3·23	...
12	Leunaphos 20—20	do	213·6	20·20	20·30	...	7·10	3·45	...

The cheapest manure of suitable composition in this list is No. 12. There have been alterations in the prices of these new manures recently, but there appears to be reasonable prospect of their settling at lower level later. Import duty of 15 per cent. *ad valorem* has recently been imposed on these ammonium phosphates, but this is not likely to continue and has not been taken into consideration above. Other manures such as urea and cyanamide, etc. have not been mentioned here although experiments have also been carried out with them. Unit for unit, however, they are not so effective as the fertilisers dealt with, and more extended experiments have not been included in the annual programmes.

CONCLUSION.

This then is the situation we have arrived at. The cultivation of rice in Burma on the present enormous scale is of comparativelly recent origin; from 1866 until the present year the paddy area has grown from 1,760,271 to 11,826,700 acres; and in this time the original virgin fertility of the soil has been largely exhausted. To maintain the standard of fertility at its present level, the indigenous manures are barely sufficient, and to increase it they are quite inadequate. To achieve the desirable end of increasing the production per acre, there are several lines of approach; improved implements and cultivation can do a little, and the use of improved and higher yielding strains of paddy can also do a little; but the total improvement which can be attained by these means is small, and a really significant increase can only be brought about by better feeding of the crop.

Before the war and for some time after, the relation between the price of paddy and the price of the artificial fertilisers which were suitable for this purpose was such that manuring of this sort could not be undertaken at

a profit. Since the war, the position has changed: the price of paddy has risen and the cost of the old manures has fallen to its previous level. Furthermore, a new class of manures has become available, peculiarly adapted to the needs of Lower Burma soils, and considerably cheaper than the sulphate of ammonia and superphosphate which have been the standard manures in the past. The consequence is that artificial manuring has now become a paying proposition for paddy, as it has been for more valuable crops in the past, and the Agricultural Department is now for the first time in a position to recommend these manures to the cultivators, with the assurance that under suitable conditions a reasonably good profit will result. It is most decidedly not intended that these manures should displace cattle manure which is still the best of all, but that they should be used to supplement what little supplies of this are available under the rather abnormal system of agriculture which obtains in Lower Burma. Thirty-six district trials were carried out with Ammo-Phos in the Southern Circle last year, and although the conditions for carrying out experiments in the district are not such as to yield data comparable in accuracy with that obtainable in a fully equipped Experiment Station, the results showed that the response to the manure was sufficient to justify the belief that the Hmawbi experience is likely to be repeated further afield. About one hundred field demonstrations are therefore being put down on cultivators' holdings this year, and, as experience accumulates, this work will be extended.

The question may be asked whether the Burmese cultivator will take to these new manures; I think he will. The process will be a slow one, but there are indications that a beginning will not be difficult to make. Bone-meal and rice bran are beginning to be bought for manurial purposes even now, and I know of one village which bought twenty tons of bone-meal last year for its paddy land. These last-mentioned substances are slow acting and return a very meagre profit, so that, when new and more profitable manures are put at his disposal, the cultivator is likely to respond. It is even just possible that experience of such manures may have an indirect effect of creating a keener appreciation of the manurial substances already at his hand. The chief difficulties lie in his chronic indebtedness and the excessive rates of interest he has to pay for any money he may have to borrow for additional expenditure, and one can only hope that the Co-operative Department may be able to do something to lighten this difficulty. Still, there is a sufficient number of land-owners with means to make a beginning, and when a conservative country like China with its traditional methods of maintaining soil fertility doubled its already considerable consumption of sulphate of ammonia between 1925 and 1926, mainly for paddy as I am informed, there appears to be no reason to doubt that some progress can be made here too.

CHEMICAL STUDIES ON COCONUT PRODUCTS.

II. UTILIZATION OF THE COCONUT.*

COCONUT, which in 1906 for a second time became nationally important to the Philippines, is now the country's second greatest export. According to the Bureau of Commerce and Industry, the yearly production of copra in the Philippines for the last ten years has been around 350 million kilograms; the value of the exported oil, copra, cake, and desiccated coconut for 1925 was P76,580,957 or about 27 per cent. of our total exports. Figures from the Statistical Bulletin of the Philippine Islands show that the Philippines furnishes about one-third of the world's supply of copra. Efforts are being made in some countries to bar coconut oil from the market that some other oils may be favoured; the final outcome will depend upon the cheapness of production of coconut oil. And the cost of production will depend not only upon proper fertilizing of the plantations, sound farm management, and marketing, but also upon the extent to which the waste products of coconut may be utilized.

The object of this paper is to review briefly the uses which the Filipinos and the industries have found for the different parts of the coconut plant, and to point out a few studies that could be made regarding some of its products.

Of the different parts of the coconut palm, namely, the roots, trunk wood, leaves, and nuts and flower spathe, hardly anything will be wasted under proper management.

THE ROOT, TRUNK AND LEAVES.

The roots contain tannin, and according to Sampson (1923) have been used as an astringent. The wood, if old and seasoned by soaking in salt water for about a month, may be used as posts, flooring, and rafters for houses; if well polished, it will serve as material for cabinet work and canes. The waste wood may be used for fuel, to make feeding troughs for pigs, and floats for fishing nets. The leaves if taken green can be used as material for screens and partitions, windows, mats, and baskets, as well as for raincapes and hats. The young leaves, called *palaspas*, are used for wrapping rice cakes called *suman*. The midribs may be used to make brooms and baskets. The young petiole may be used for tieing purposes. From the fibrous stipule, brushes and hats and native raincapes may be made; it can be used also as substitute for horsehair for stiffening clothing and furniture (Sampson, 1923). The fibres in the inner spathe are used in place of rope for tieing fences; this rope stands the weather as well as any other.

In case the coconut plant is found unproductive or is attacked by some disease, it may be cut done and the young stem tissues, the cabbage, may be used for food as a salad. The leaves, when burned, yield an ash rich in soda potash and phosphoric acid which may be used for making soap, or as a constituent of fertilisers.

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* By N. Galvez R. Moreno, and V. G. Lava in *The Philippine Agriculturist,* Vol. XVII, No. 4, September, 1928.

THE NUT.

Of all the parts of the coconut, the nuts give the most income. From these come the meat, the water, the shell, and the husk. The meat may be taken fresh from the nuts and, when cleaned and shredded and thoroughly dried under partial vacuum, the product is sold as desiccated coconut; this is widely used as an ingredient in puddings, cakes, pastries, and candies.

Locally, the fresh meat is grated and pressed with hot water to give a thick emulsion called *gata*. This is used much the same as cow's milk in making various desserts; it is also heated and the oil separated, leaving a nitrogenous residue, *latek*. Both the oil and latek are used for food.

The meat and water of the young coconut, known as the *buko*, are widely used on warm days, in much the same way as ice cream or cooling drinks. In localities where the source of water is not well known or considered sanitary, travellers rely wholly upon the water of the young coconut. Furthermore, it has been observed that young coconut water is a good diuretic.

When grated meat is dried with sugar the product is commonly known as *bukayo*, a sweet very much in demand among the Filipinos.

The bulk, however, of fresh meat is first treated to produce the copra which is later pressed for oil. This is the method used to prepare oil on a commercial scale. The oil may be used directly in the manufacture of soap and candles. The crude oil is sometimes used by Filipinos for illuminating purposes. Soaps prepared exclusively from pure coconut oil were shown by Walker (1926) to be very effective disinfectants against typhoid bacilli, paratyphoid bacilli, and dysentry bacilli. The stability of pure coconut oil makes it a good ingredient in the manufacture of many toilet preparations, such as creams and pomades. Experiments on the rate of hydrolysis of coconut oil, carried out in the Chemistry Laboratory in this College show that when placed in a glass container, pure coconut oil hydrolyses to only a very slight extent.

Table 1.

Showing rate of hydrolysis of pure coconut oil.

Amount of water mixed with the oil	Oleic acid at the beginning		Oleic acid at the end of 4 months		Rancidity.
	Covered	Uncovered	Covered	Uncovered	
per cent.	per cent.	per cent.	per cent.	per cent.	
37·61	·15	·15	·44	·44	Negative
38·71	·15	·15	·60	·45	,,
23·11	·15	·15	·60	·45	,,
16·81	·15	·15	·45	·60	,,
10·00	·23	·23	·46	·53	,,
3·96	·23	·23	·46	·46	,,
·11	·23	·23	·31	·31	,,

From table 1 it is evident that pure or refined coconut oil may be used in the manufacture of vegetable lard, oleomargarine and ointment; in fact, stable emulsions, such as mayonnaise, etc., have been prepared by Ayre (1923) from refined coconut oil.

Coconut oil has been shown by Cohn (1924) to be an adulterant of cacao butter, and Southcombe and Wells (1920) have shown that it can be used as an adulterant in lubricants. It has been recommended by Spiers

and Bitte (1926) as a constituent in the preparation of a mixture for oiling scoured wool. Keghel (1913) found it very useful as a constituent of a solution for the industrial preservation of eggs. Artificial petroleum which has been prepared from soybean oil and fish oil has been prepared by Kobayashi (1921) from coconut oil by heating the oil with Japanese acid clay. It has, furthermore, been found by Rivera (1925) that coconut oil has a slight curative effect on leprosy. When the oil is subjected to distillation with one to two per cent. sulphuric acid, the fatty acids and the glycerol are separated. Clycerol can be obtained also as a by-product in the manufacture of soap.

COPRA CAKE.

The residue, after pressing the copra for oil, is called copra meal or copra cake. It contains about 10 per cent. of oil and 17-18 per cent. of protein. Copra cake is generally used as cattle and chicken feed. According to Lindsey (1914) its nutritive value is equal to that of gluten feed, and if given in sufficient amount to cows it helps in producing butter which is firm in texture; further-more, Ewing and Spence (1918) found that butter from copra cake-fed cows has a high fat content. In the East Indies, copra meal has been suggested by Jansen (1921) as a useful protein for man when food is scarce. A combination of copra meal and rice bran has been shown by Allas (1924) to be a good supplement to camote vines for feed for growing pigs. However, Sulit (1926) found that if the cake is given in great amounts to rats it acts as poison.

Copra cake is valuable also a fertilizer. Jaojoco (1923) found that the cake contains 19·89 per cent. P_2O_5 and 8·14 per cent. K_2O.

COCONUT WATER.

The water of the coconut may be used for making fermented beverages, the Filipinos mix the water with corn starch and make vinegar. According to Leonard (1925) coconut water which has been allowed to ferment for four to five days will coagulate rubber latex and produce a rubber of good colour and purity.

COCONUT SHELL AND HUSK.

Various uses are made of the shell of the coconut. It is often made into bowls for ornamental purposes, into household utensils, carved articles, rubber-tapping cups and stringed instruments. According to the patent of Schwinger (1915) the shell may be used in the manufacture of colored buttons, and the shavings of the shell used for polishing hard colored articles. It is used also in the manufacture of corks. The shell is a good fuel, either as charcoal or untreated. The charcoal when properly prepared is extensively used in the refining of sugar, decolorizing of colored liquids, etc., and as an ingredient in the chemical purifiers in gas masks. It has been used by Shober (1910) as an absorbent in radium therapy. Coconut shell charcoal also serves as a catalyst in the production of alcohols and aldehydes from gaseous hydrocarbons. Kloppenburg (1924) synthesized methyl alcohol and formaldehyde from methane by oxidizing the hydrocarbon in the presence of coconut charcoal.

When a mixture of shell and coconut husk is subjected to distillation, an acid liquid is distilled. The distillate has been found by Stevens (1921) to coagulate rubber. When the shell or the husk is burned, it produces an ash rich in soda, potash, and phosphoric acid. Hence, the ash may serve as a source of alkali in the manufacture of soap or as a constituent of fertilisers.

From the husk, coir fibres that can be used in the manufacture of rope, twine, matting, rugs, and carpet and also for brushes and brooms and mops may be made. It has been calculated by Holonesky (1920) that from 1000 husks, 60 kilograms of spinnable fibre and 7·5 to 12·5 kilograms of stuffing fibre may be obtained. The spinnable fibre can be used, according to Von Uffel (1919), in manufacturing fire-proof roofing. There are a number of uses for the coir fibre. It is used in the place of hemp in the manufacture of rope and twine. Cordage made from the coir stands exposure to weather and water better than that made from some other fibres. The coir is also used for making door mats and floor mops. According to Sampson (1923), coir fibre is even made into belting for driving machinery. The stuffing fibres may be used in the manufacture of corks. The possibility of using coconut fibre as a raw material for some classes of paper or paper pulp has been suggested by Richmond (1906). The fibres also serve as a good fuel and for stopping of leakage.

THE FLOWER SPATHE.

In many localities the coconut is raised not for the nuts but for the flower spathe. This, on being cut properly, yields toddy which may be used as a beverage, either fresh or fermented, or it may be made into syrup, palm sugar, or vinegar.

SUMMARY.

The coconut products which are very much in demand at the present time are oil, copra, copra cake, and desiccated coconut. During the world war, coconut charcoal was extensively utilized in making gas masks, and with proper preparation it may be used for refining sugar. The sap from the spathe is extensively used in making fermented beverages. In passing, it may be pointed out that at the present price of the fermented drink in the Philippines, it is more than twice as profitable to cultivate the coconut for the toddy than for the copra. Coconut coir is used in the manufacture of cordage and upholstering.

It would be interesting to find out whether the system practised in the sugar centrals as applied to sugar production cannot be applied in coconut plantations. Conditions under which copra is handled make the price of the oil relatively much higher than if it were obtained directly from the fresh nuts. These conditions are; under the present method of handling copra for export a large percentage of the oil is lost in transit owing to the action of moulds; the inconvenience of handling copra because of the impurities, such as sand, nails, etc., deliberately thrown in by the middlemen; and that, in order to get high grade oil, refining is necessary. The main difficulty in obtaining the oil from fresh coconut meat seems to be the lack of knowledge about the method of separating the protein colloids from the oil.

Other important investigations that my be carried out with profit are the utilization of copra cake for fertilizer and food, and the manufacture of charcoal for sugar refining from coconut shell.

SOME POSSIBILITIES IN BREEDING PLANTS USED FOR COVER, GREEN MANURE AND SHADE.*

THE greatest development in the use of plants for cover, green manure and shade is found in countries where permanent crops are grown on the scale of an estate as in Java, Sumatra, Federated Malay States and probably also in India, Ceylon, and other countries. In these regions perennial crops such as rubber, cinchona, coconut, oil palm, tea, coffee and the like are more important sources of profit than some annuals like rice, maize and similar food plants.

In Java, estate managers wage a constant war against weeds. This fight is so intense that to eradicate and control the weeds either the clean culture system is employed or cover crops are grown not only between rows of plants but in every conceivable nook and available spot on the plantation, even right in the paths and roads of the farm. Some of the cover plant species used are also turned under as green manure or used to shade nursery plants and those newly transplanted in the field.

The largest collection I have seen of plants used and being tested as green manure, and for covering spaces between cultivated plants to control weeds, and for shading nursery plants and young plants in the field —aid plants, as they may be called for brevity—is that belonging to the Tea Experiment Station at Buitenzorg, Java. The collection consists of plants already in general use as well as wild plants collected in Java and of plants of different species from many tropical countries. Any one interested in the list of the aid plants used in Java should consult the work of Baker and van Slooten (1924) for cover and shade plants and green manures and of Wigman (1926) for road trees. Some of the most important species in the collection are *Acacia decurrens* Wild., *Cajanus cajan* Millsp., *Calopogonium mucunoides* Desm., *Cassia mimosoides* L., *Crotalaria anagyroides* H.B.K., *Crotalaria usaramoensis* Baker, *Desmodium gyroides* D.C., *Indigofera endecaphylla* Jacq., *Indigofera sumatrana* Gaertn., *Leucaena glauca* (L.) Benth., *Mimosa invisa* Mart., *Sesbania grandiflora* Pers., *Tephrosia noctiflora* Bojer., *Tephrosia Vogelii* Hook., and *Vigna Hosei* Backer.

The strange thing about the use of these aid plants is that, with few exceptions, no thought has been given to selection, even among the varieties making up each species, not to speak of individual strains and plants within a variety. The unit taken so far has been usually the species, and when one of these does not satisfy, the tendency, naturally, has been to follow the route of least resistance, namely, the trial and use of other species. This is passing strange when it is realized that the use of cover crops, green manures, and shade plants is as essential as the planting of the regular economic plants with which they are generally grown and that many species in use, despite their undesirable characters, have never been replaced by others.

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* By Nemesio B. Mendiola in *The Philippine Agriculturist*, Vol. XVII., No. 4., September, 1928.

Road plants are more or less permanent in nature and the choice not only of proper species for a given locality but also of varieties and healthy and vigorous plant materials cannot be over-emphasized. Practically no attention is given to this phase of the work. Seedlings of different varieties and ages are planted promiscuously. It is time that some serious thought be given to this point by those in charge of the roads.

There are still so many species of plants untried for their value as shade plants and as cover plants and green manures that for a long time experiment stations and estate managers and planters have been content to try uninvestigated species to replace undesirable ones in use instead of performing selection or improvement with them. The time seems to be approaching, however, when plant breeding will be called upon to improve some of the most valuable species now under cultivation. The cause of the failure of some of these plants to keep up their reputation has been the lack of selection. For example, formerly, *Erythrina* species were in high esteem as shade trees. According to Alberts, lack of proper selection has been one of the main causes of its being less important at present in this respect than *Leucaena glauca.*

That the species widely used have their respective defects is known to all those who have had long experience in using them. Some examples may be cited. *Mimosa invisa* Mart. is considered one of the best, if not the best, species for use in eradicating and controlling weeds, and is generally used in eradicating the *cogon,* or *alang-alang* (*Imperata cylindrica* (L.) Beauv.). *M. invisa* produces an abundance of seeds, is self-sowing, or self-perpetuating, grows satisfactorily, and is not troubled by insects or disease. It gives a good amount of humus and is a good green manure. Its only defect seems to be that its stem is thorny. When it is so planted that a roller can be used to bring it down before it is plowed under, the thorniness is not a very great disadvantage. Under some circumstances a roller cannot be used and it has to be handled by labourers who greatly dislike the thorns for they cause scratches and pricks which at times require prolonged medical treatment. It has been said that a thornless variety of this species would be worth a million pesos. Mr. L. Koch of the General Experiment Station at Buitenzorg made an attempt to select plants on the basis of the length of the thorn with a view to ultimately eliminating it, but no positive results were obtained. Here, then, is a wide field for service for plant breeders. Mr. A. A. M. N. Keuchenius, who is in charge of the green manure and cover crop garden of the Tea Experiment Station in Java told the writer he was trying to attack this thorn problem with the *M. invisa* by crossing it with *Neptunia plena,* which is thornless and looks somewhat like the *Mimosa,* although not so thickly growing. Let us hope a thornless hybrid will be produced that is *M. invisa* in many respects but is without the thorn.

Meanwhile our local Bureau of Agriculture is forced to study the questions as to whether the propagation of *Mimosa invisa* in the Philippines should be allowed or should be prohibited because it might become an undesirable weed. Were it spineless there would be no hesitation in encouraging the spread of this very important legume.

Leucaena glauca is used generally in Java, especially on tea estates as a shade plant. It is periodically pruned. It is also planted thickly as a low hedge along the edges of the terraces to prevent erosion on slopes. The roots of *Leucaena* penetrate the ground so deeply, even the hard subsoils. That in certain places it has been used to drill holes through land subsoil for purposes of drainage. This species is not troubled by leaf disease. The main defect of *Leucaena glauca* as a shade plant is that it grows so fast and recovers so fast after pruning that the cost of upkeep is rather high. For this reason the Tea Experiment Station at Buitenzorg is trying to find some other species better than *L. glauca*. Another defect of *L. glauca* is that it is a heavy seed producer, and drops seeds constantly, and the seedlings from these seeds, especially in places of fairly uniform rainfall throughout the year, make frequent weeding necessary. Doctor Cramer of Java once started selection of parent trees with a sparse seeding habit to eliminate this special defect and this work evidently was attended with success. It is said that sterile and almost sterile strains were found.

Experiment stations in other countries may follow the examples set by Dutch plant breeders in Java. They can enlarge the scope of their work by thoroughly studying the plant breeding possibilities with the plants they use for cover, green manure, and shade, and start isolation and hybridization work with these important aid plants.

WOODINESS OF PASSION FRUIT.*

THE woodiness disease of passion fruit has long been known as a serious disease in New South Wales. The condition is most readily recognized in the fruits, which are quite hard and woody in contrast to normal fruits.

Healthy fruits are somewhat ovoid in shape, and on drying slightly become shrivelled in a characteristic manner. Woody fruits are generally stunted and deformed. They are occasionally spherical in shape, and this feature, coupled with the hardness and purplish leaden colour ot the fruit, has given rise to another common name for the disease, viz., "bullet."

The skin or rind of such fruits is abnormally thickened, and is often accompanied by a certain amount of cracking and scaliness of the outer layers. These fruits can only be cut through with difficulty, and are then observed to contain only a limited supply of pulp of inferior quality. Although the disease is most commonly observed on the mature fruits, symptoms of the disease may be observed in fruits in all stages of development. In severe cases, many of the younger fruits fail to mature and fall from the vines.

In addition to these marked symptoms on the fruits, the disease is aslo characterised by certain abnormalities of the shoots and foliage of the vines. Such vines generally have a stunted and deteriorated appearance. The leaves, particularly of the terminal shoots, are smaller than normal leaves, and frequently are puckered, curled and twisted. On closer examination it is seen that such leaves do not possess a normal green coloration, but are either pale yellowish-green or have a mottled appearance, due to the presence of light-green and dark-green areas. Secondary symptoms of the disease may be observed on the older mature leaves. Although at first normal in appearance, such leaves may later develop a series of small, pale-yellowish spots, particularly in the areas between the veins. These spots should not be confused with the discolorations caused by the brown spot fungus *Gloeosporium fructigenum*.

The disease is most commonly observed during the winter months, although severely diseased vines may be seen throughout the year. Individual vines only may be affected, or the disease may be widespread throughout a plantation. Slightly diseased vines, which have produced a few woody fruits during the winter months, may subsequently produce normal fruits during the summer months, but such vines are not as productive as normal vines.

Although the disease is most apparent on older vines, close examination will often reveal that it is present in young vines, and even in young seedlings, and it is most important that the symptoms of the disease on the leaves and shoots should be fully appreciated in order that control measures should be most effectively applied.

Many different theories have been advanced as to the cause of the disease, but it has now been established that it is due to the action of a virus. The virus is infectious in character, and is present in the sap of

* By R. J. Noble in *The Agricultural Gazette of New South Wales*, Vol. XXXIX, Part 9., September 1928.

diseased vines. Diseased vines represent sources of infection and are, therefore, a menace to adjacent healthy vines. The disease was readily transferred by mechanical means in the infection experiments, and it is very likely that this is the most common method of transmission of the disease under field conditions. Infection may be carried on the hands of those working among the vines when pruning, rubbing off the early shoots, and in tying the vines to the supporting stakes and wires. Insects which feed on diseased vines and then migrate to healthy vines may also be concerned in spreading the disease. Passion vines, however, are not very subject to visitation by insect pests, and this aspect is probably not of great importance under commercial conditions.

CONTROL MEASURES.

1. Seedlings should not be raised in proximity to diseased vines. The seedlings should be closely inspected at frequent intervals, and those showing signs of disease in the leaves should be removed and destroyed. Only healthy seedlings should be planted out.

2. After planting out, the vines should be carefully and systematically inspected at intervals, and again any diseased vines which are observed should be immediately removed and destroyed. Such vines should not be pruned. Replacements may be safely made shortly after removal of the diseased vines. The hands and knives should be well washed in soapy water after dealing with a diseased vine and before working with healthy vines.

3. When the disease is observed to be fairly widespread in an older plantation, the vines should never be pruned in October or November with a view to the production of a winter crop. Such action will result in removal of the summer crop, and the subsequent winter crop will contain a high percentage of worthless woody fruits.

4. Older areas of vines should be cut down and destroyed as soon as they become commercially unprofitable. They should not be allowed to remain in a neglected condition, as they are a source of dangerous infection to adjacent young vines.

5. Severely diseased individual vines in older plantations should be first cut off at the ground level and allowed to dry out before removal. This procedure is less likely to cause injury and subsequent infection of the adjacent vines which have become intergrown with the diseased vine on the supporting wires.

6. Remove all weeds and other material which may harbour insects in proximity to the vines. Sprays cannot be applied effectively to passion vines under commercial conditions; thus it is all the more necessary for other means to be adopted to minimise possible insect infestation.

PRESENT STATUS OF CERTAIN INSECT PESTS UNDER BIOLOGICAL CONTROL IN HAWAII.*

[*Note.*—The biological control of insect pests is a subject to which much attention has been given in certain countries, particularly the United States of America and the Hawaiian Islands. The importance of this aspect of pest control is now being more widely appreciated and reference was made in the last number of this journal to the work of the recently established Parasite Laboratory of the Imperial Bureau of Entomology in England.

Two articles relating to the introduction into Hawaii and Fiji of enemies of the pests of some of the more important crops of these countries are of interest to Ceylon and are reproduced here.

Spodoptera mauritia, referred to in the first article, will be recognised as the paddy swarming caterpillar of Ceylon which is occasionally responsible for serious losses in the paddy-growing areas of the North Central and Eastern Provinces. A species of *Cirphis* is also recorded locally as a pest of paddy. Other Hawaiian pests represented in Ceylon are *Pseudococcus filamentosus* and *Chaetodacus curcubitae.*

Aspidiotus destructor, which is a serious pest of coconuts and plantains in Fiji. is also a pest of the same and other plants in Ceylon, and an account of the introduction of natural enemies of this scale into Fiji is given in the second article.—*Ed. T.A.*]

Perhaps it is generally known that in the Hawaiian Islands remarkable success has been attained in the control of insect pests by the introduction of their natural enemies from other countries. As in many other places, so in Hawaii the worst pests are not native insects, but introduced species that have gained admission in some way through the channels of commerce. We have had a number of very destructive ones in Hawaii. The work of the entomologists in searching for natural enemies in the homes of these pests and their introduction to Hawaii began in 1893 by the employment at that time of the late Albert Koebele for this purpose. As a matter of fact one very valuable ladybeetle had been introduced before that time by Mr. Koebele, namely, *Novius cardinalis* (Muls.) in 1890, after it had become established in California in controlling the cottony cushion scale (*Icerya purchasi* Mask.). This ladybeetle proved as successful in Hawaii as it had in California in controlling the cottony cushion scale. This pest was very severe on fruit trees and ornamental trees and shrubs before the establishment of the ladybeetle. It was soon brought under control, and for a long time now has not been of any importance as a pest. Its present status is that it maintains its existence, and small colonies are occasionally met with which are soon destroyed by the arrival of the ladybeetle. Serious injury is done only in cases of isolated, very small trees, as young seedlings becoming infested, or young nursery stock, in which cases the small plants may be badly injured by the cottony cushion scale before the ladybeetles increase sufficiently to reduce the pest colony.

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* By O. H. Swezey, Entomologist, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii, in *The Journal of Economic Entomology,* Vol. 21, No. 5, October 1928.

SUGAR CANE LEAFHOPPER (*PERKINSIELLA SACCHARICIDIA* KIRK).

The most destructive pest in Hawaii has been the sugar cane leafhopper. It was most probably introduced from Australia in imported cane cuttings for planting more than thirty years ago. By 1902, it was attracting attention in all the sugar cane districts of the islands and causing considerable alarm. By 1904 it was causing an estimated loss of $3,000,000 annually and threatening the sugar industry with ruin. Parasite introduction began the previous year. The successfully introduced parasites were as follows:

Egg-parasites:	*Paranagrus optabilis* Perkins.	Queensland,	1904
	,, *perforator* Perkins.	,,	1904
	Anagrus frequens Perkins.	,,	1904
	Ootetrastichus beatus Perkins.	Fiji,	1905
	,, *formosanus* Timb.	Formosa,	1916
Drynidae:	*Haplogonatopus vitiensis* Perkins.	Fiji,	1906
	Pseudogonatopus hospes Perkins.	China,	1907
Egg-sucking bug:	*Cyrtorhinus mundulus* Bredd.	Queensland and Fiji,	1920

Of the earlier introductions, the egg-parasites were the most effective and of them *Paranagrus optabilis* the best of all. With their establishment, together with the help of quite a number of native parasites and predators, the leafhopper pest was gradually reduced so that by 1917 in most plantations very little damage was done by leafhoppers. A few plantations were still suffering considerably. After the establishment in 1922 of the *Cyrtorhinus* bug which sucks the eggs, the pest was still further reduced, so that finally it was under complete control.

The present status of the leafhopper is that it is very scarce and hard to find in the most of the sugar cane area. In an occasional instance they become noticeable but not abundant enough to be injurious. Their enemies, especially the *Cyrtorhinus,* soon appear and increase so as to reduce the pest again to scarcity. A great deal of work is being done in the propagating of seedling varieties, and occasionally a few among these seem more susceptible to leafhopper, or at any rate they may become more conspicuously populous with leafhoppers than the others. At times, too, the leafhoppers become more numerous in fields of cane that are affected with the eyespot disease.

At the present time, it is the usual condition of the cane to be free from the honeydew of the leafhopper; whereas, in the years when the leafhopper pest prevailed, the cane was always sticky with the honeydew and the leaves covered by sooty mold which flourished in the honeydew. It was impossible to enter a cane field without at once becoming messed up with this honeydew and black mold. Now one encounters no such difficulty, for the cane leaves are usually clean.

THE SUGAR CANE WEEVIL BORER (*RHABDOCNEMIS OBSCURA* BOISD.).

This cane borer has for a long time been an important pest. It was known as a cane pest as long ago as in the '60's and is thought to have been introduced from Tahiti with cane cuttings for planting at an earlier date. It became generally dispersed throughout the Islands and in some places wrought great havoc in the cane fields. Sometimes fields of cane would be half destroyed. Various practices were made use of to try to check it, but with little effect, and there was an annual loss that must have amounted into the millions. However, after the New Guinea Tachinid (*Ceromasia sphenophori* Vill.) was discovered, and introduced in 1910, there began to be a reduction in the number of borers, and a consequent reduction of the loss

of cane by them. In one of the plantations that was most subject to losses by the borer, in three years the number of infested canes fell from 30 to 12·77 per cent, with a resultant increase of about ·7 ton of sugar per acre, or about 1,400 tons of sugar for the whole plantation annually, equivalent to a saving of more than $100,000. On another one of the worst borer-infested plantations, in four years, due to the reduction of borer damage, the yield of sugar per acre increased by 2 tons, or a saving of nearly $100,000 to the plantation. Conditions continued to improve until now, after 18 years, the loss by borer is negligible for the greater part of the sugar cane area. There still are borers on all of the plantations, but, on those so situated as to be the least favourable to the borer, the parasite keeps them reduced to such scarcity as to be ignored. In other situations their numbers increase, even up to an infestation of 30 per cent. of the canes. This does not mean a loss of 30 per cent. for many of the infested canes are not entirely destroyed but still are of some value for sugar. Usually, nowadays, these most severe borer infestations are where there is a great growth of cane of two years' growth or more, and much of it decumbent and buried by the fallen dead cane leaves, so that the borers in these canes are where they cannot be reached by the parasites, hence can increase in numbers unchecked and with a consequent increase in injury to the cane. So that, although there is an enormous saving due to the work of the parasite in checking the borer, the latter still causes thousands of dollors losses to some of the plantations. The estimate last year on one of the plantations having the greatest borer damage was a loss of $200,000. On the other hand, when examining the borer injury, or hunting for borers in most regions, the borers are nearly all found to be parasitized, fully demonstrating the value of the parasite in controlling the pest.

CANE ROOT GRUB (*ANOMALA ORIENTALIS* WATERH.).

This pest made its appearance in cane fields as recent as 1912. It spread from one locality until it was causing a loss of $50,000 annually to two plantations partially infested by it, before its spread was checked by an introduced parasite and it was reduced to harmless numbers. The parasite in this case was a digger wasp (*Scolia manilae* Ashm.) from the Philippines, which was introduced in 1916, and soon increased rapidly, destroying the grubs and checking the spread of the pest, so that within two years the damage done by them had been reduced to insignificance. Now a specimen of either the grub or beetle is seldom found. Thus was checked a pest that otherwise would have become spread throughout the cane area on the island of Oahu, and no doubt eventually to the other Islands.

ARMYWORMS (*CIRPHIS UNIPUNCTA* HAW, and *SPODOPTERA MAURITIA* BOISD.).

There have been outbreaks by these two common armyworms, usually annually for many years, especially in those sugar plantations situated adjacent to grasslands, or having fields infested with nutgrass which is the favourite food of *S. mauritia*. Parasites have been introduced at various times and from various places until now armyworms are so well controlled that outbreaks seldom occur on most of the Islands, and not so often or so extensive on the island of Hawaii where these outbreaks have been the most prevalent. This has been the case especially since the introduction from Mexico in 1923 and 1924 of *Euplectrus platyhypenae* Howard and *Archytas cirphis* Curran. Other valuable parasites working on armyworms here are *Amblyteles koebelei* Swezey, *Amblyteles purpurepennis* Cress., *Hyposoter exiguae* Viereck, *Chaetogaedia monticola* Bigot and *Frontina archippivora* Will., all from California, and an egg-parasite, *Telenomus nawai* Ashm. from Japan.

GREY SUGAR CANE MEALYBUG (*PSEUDOCOCCUS BONINSIS* KUWANA).

This mealybug is so completely controlled by *Pseudococcobius terryi* Fullaway as to be rarely met with. This parasite does not attack the pink sugar cane mealybug, *Trionymus sacchari* Ckll., and this mealybug is found generally prevalent in all cane fields though not rated as a serious pest. A number of ladybeetles that feed on mealybugs have been introduced, but they do not feed to any extent on the pink sugar cane mealybug.

AVOCADO MEALYBUG (*PSEUDOCOCCUS NIPAE* MASK.)

Introduced ladybeetles fed on this mealybug to some extent but apparently exercised no control. Avocado trees always had the leaves badly covered by this mealybug. It also badly infested fig, mulberry, guava, coconut and some other trees as well. Finally the little parasite, *Pseudaphycus utilis* Timb., was introduced from Mexico in 1922. It quickly became established and spread throughout Oahu, and was distributed to the other Islands where it spread similarly. In about two years the avocado mealybug was practically exterminated. The leaves of avocado now remain clean, as do also the leaves of the other trees mentioned that were formerly infested by *nipae*. No infestations are found on any of these trees. It has been a most remarkable case, both as to rapidity of spread of the introduced parasite and the completeness of its work on the host insect.

COTTONY MEALYBUG (*PSEUDOCOCCUS FILAMENTOSUS* CKLL.)

A parasite was introduced for this mealybug in 1925 from Honkong. It is *Anagyrus dactylopii* Howard. It readily became established, and the mealybug has become scarce. Possibly it may become as well controlled as is *P. nipae*.

PLANT LICE.

A number of the common plant lice have been troublesome in the past and quite a number of ladybeetles and other enemies have been introduced at various times. At present all of these working together seem to keep most plant lice from becoming serious. Often there may be an outbreak which appears serious for a time, but the ladybeetles and other aphis enemies soon find them and quickly check and eliminate the pest. Probably the plant lice are as well controlled in this way as in any other country. Seldom does any one practise spraying or dusting for these outbreaks of plant lice.

MEDITERRANEAN FRUITFLY (*CERATITIS CAPITATA* WIED.).

This pest made its appearance in 1910 and soon became generally spread, severely attacking nearly all kinds of fruit of importance except banana, avocado (slightly), and pineapple. Of the common fruits perhaps the peach, mango and guava were the worst attacked, it being next to impossible to obtain a fruit of these free from maggots.

The following parasites have been introduced:

Opius humilis Silv. from Africa in 1913.
Diachasma tryoni Cam. from Australia in 1913.
,, *fullawayi* Silv. from Africa in 1914.
Tetrastichus giffardianus Silv. from Africa in 1914.
Dirhinus giffardii Silv. from Africa in 1913.

Records that have been kept of the work of these parasites during the past few years show that on the average about 55 per cent. of the fruitfly maggots are destroyed by the parasites. In coffee cherries practically all maggots are parasitized, and in the case of mangoes, though the parasites do not reach many of the maggots in the fruits, yet the fact that many mangoes escape being infested indicates a considerable reduction of the fruitfly. The guava serves also as an index, for, whereas nearly all guavas on the bushes occurring wild in the valleys and hills were infested by fruitfly, at the present time a good proportion escape becoming infested.

MELONFLY (*CHAETODACUS CUCURBITAE* COQ.,)

This pest gained access to Hawaii about 1895, and soon put a stop to the sucessful growing of melons. It is said that before that time fine watermelons were grown in great abundance, and also canteloupes, but after the arrival of the melonfly from the Orient these were grown with great difficulty and mostly disappeared from the market. All cucurbitaceous fruits became badly infested and tomatoes as well. The parasite, *Opius fletcheri* Silv., was introduced from India in 1916. It has done good work against the melonfly in the gardens as shown by the abundance of watermelons the past few years, some canteloupes also. The watermelons, too, are on the markets for a period of several months each summer. Another conspicuous indication that the melonfly is pretty well controlled is that perfect cucumbers are obtainable in abundance the year round in Honolulu, whereas, before the introduction of the parasite, it was difficult to get good ones, they being mostly ill-shaped from having been infested by the melonfly maggots, yet survived sufficiently so that they were for sale by the vegetable pedlars. Tomatoes too are not nearly so badly infested any more.

MESQUITE OR ALGAROBA BRUCHIDS.

Several species of bruchids have become established in Hawaii of recent years. Among them the following four feed in the algaroba pods. *Bruchus prosopis* Lec. has been known for over 20 years; *Pachymerus gonagra* Fab. first known in 1908; *Bruchus sallaei* Sharp in 1918; *Bruchus amicus* Horn in 1923. These algaroba pods grow in quantity and are much uesd as stock food. With these four bruchids infesting them, their value was greatly diminished, especially if stored for any length of time. The following parasites have been introduced from Texas:

Egg-parasite: *Uscana semifumipennis* Gir., 1910.
Larval parasites: *Heterospilus prosopidis* Vier., 1910.
Lariophagus texanus Cwfd., 1921.
Urosigalphus bruchi Cwfd., 1921.
Glyptocolastes bruchivorus Cwfd., 1921.
Horismenus sp., 1921.

By the combined work of all these parasites, the abovementioned bruchids are now controlled to the extent that the algaroba pods are mostly free from serious injury and their value as stock food scarcely deteriorated. Probably the egg-parasite is the most effective of these parasites.

SCALE INSECTS.

There are a large number of the cosmopolitan scales which attack many kinds of trees and shrubs in orchards, gardens and lawns in Hawaii. Numerous parasites and several ladybeetles have been introduced, intentionally or otherwise, and exercise a certain amount of control, though usually not complete control. However, these scales are usually so well controlled that little effort is made to control them by insecticides. Time does not allow for taking up these individually or in detail.

As a whole the insect pests in Hawaii are pretty satisfactorily controlled by the biological methods. However, there are some not yet sufficiently controlled and thus there remains for the entomologists the problem of searching and securing more of the natural enemies for introduction. It is likely, too, that in some cases success will not be thus attained. For example, the hornfly pest on cattle seems to be a most difficult problem to solve in this way. Several attempts have been made to find and introduce parasites or predators to combat this pest, but so far no progress in natural control has been obtained. The recent introduction of a bird, *Ripidura tricolor* (willy wagtail), from Australia, where it is noted as a valuable enemy to cattle flies, may prove of some benefit when it becomes sufficiently numerous.

PROGRESS REPORT ON THE COCCINELLIDAE IMPORTED FROM TRINIDAD TO CONTROL ASPIDIOTUS DESTRUCTOR.*

1. SPECIES INTRODUCED.

Five species were landed in Fiji on 6th March. These were:

(1) *Cryptognatha nodiceps, Mshl.*	...	1,517
(2) *Azya trinitatis, Mshl.*	...	162
(3) *Pentilia insidiosa, Muls.*	...	22
(4) "Spotted" sp. (unidentified)	...	69
(5) "Small" sp. (unidentified)	...	400

The figures indicate the numbers landed alive in the Trinidad cages.

2. PRELIMINARY ATTEMPTS AT BREEDING IN FIJI.

Although the numbers landed were small in some cases they would have been ample for breeding purposes had the conditions prevailing in Fiji been the same as those in Trinidad. With the exception of *C. nodiceps*, however, none of the species bred satisfactorily.

It is possible that the very wet, cold weather which prevailed during April partially accounted for the failure of these species; but the fact that they bred satisfactorily during the voyage from Trinidad, in spite of the very adverse conditions (notably, extreme heat, great humidity and partial darkness) to which they were at times unavoidably subjected, testifies to their hardihood and makes it improbable that climatic conditions in Fiji were in any way responsible for their failure.

All the species except (1) were heavily attacked by ants in the Fiji cages, and there is no doubt that ants were the chief cause of the failure. Species (3), (4) and (5) were almost wiped out by them. Ants have been observed attacking and carrying off living larvae and pupae of these three species. This difficulty was largely overcome by tanglefooting the cages and varas, but in the meantime the stock of beetles had become so depleted in all species except *C. nodiceps* that it was considered too risky to leave the few remaining adults in the cages. We therefore decided to attempt breeding in tubes in order that closer watch might be kept on all individuals and ants completely excluded. Tube-breeding has presented many difficulties, however, and, although it saved the situation, we now have no more individuals of species (2), (3) and (5) than we had on 6th March.

It is almost certain that *C. nodiceps* is also attacked by ants, but we have come to the conclusion that its success, in spite of ants, is due to the fact that it has been present from the first in much larger numbers than the others, so that the number destroyed by ants is negligible by comparison. Further, the life cycle of this species is shorter and its rate of multiplication therefore greater than any of the others; hence it is better able to withstand the attacks of ants.

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* By T. H. C. Taylor in *The Agricultural Journal of the Department of Agriculture, Fiji.* Vol. 1, No. 1, 1928.

3. CRYPTOGNATHA NODICEPS.

Tube-breeding proved satisfactory for this species, but is unnecessary. It multiplies so rapidly in the cages that we sometimes have great difficulty in maintaining a sufficient supply of scale, but the chief difficulty arises through its very strong cannibalistic tendencies, even when an abundant supply of scale is present.

Two colonies of *C. nodiceps* have already been liberated, and we hope to have sufficient adults (about 1,000) for three more colonies a fortnight hence.

4. AZYA TRINITATIS.

This species has been very disappointing. In Trinidad, except for *C. nodiceps*, this is the most efficient species, yet in Fiji it will scarcely breed at all; and although ants have been troublesome at times they are now completely excluded. We cannot yet explain the failure of *Azya* satisfactorily. It will not oviposit in tubes, and even in the cages very few eggs are laid. Many larvae die for no apparent reason, and those which survive grow extremely slowly. On the ship it bred well in the cages without much attention, even when the food supply ran short, and its failure in Fiji is therefore all the more puzzling. The most satisfactory method of breeding it seems to be to enclose the adults in thin cloth bags over varas, an alternative measure which was adopted with great success for all species on the ship. The only explanation which we can offer for the failure of *Azya* is that there is some difference between the scale in Fiji and that in Trinidad.

5. PENTILIA INSIDIOSA.

Adults lay well in tubes, but the majority of the eggs obtained in this way were killed by mildew on the strips of leaf on which they were laid. This difficulty has now been overcome, but the stock has become very low in the meantime. It will be necessary to continue breeding in the tubes for another month at least, and no adults will be available for liberation for at least two months.

6. "SPOTTED" SP.

This species is promising. Much difficulty was experienced with it at first owing to ants, but it laid well in tubes, and by means of tube-breeding we have been able to obtain sufficient numbers to put in a cage where it is now breeding very well. It is probably unwise to liberate this species until about 400 adults are available and this will not be for another month or more.

7. "SMALL" SP.

This species is particularly liable to be attacked by ants, and it is the only one which is attacked by them in the adult stage as well as in the early stages. At present, tube-breeding, which proves satisfactory, must be continued. One colony was liberated on Wakaya in March, but there will not be sufficient adults for further colonies for some time yet.

8. LIBERATIONS.

Colonies have been liberated as follows: *C. nodiceps*. (1) 500 at Koro Levu, Wakaya, on 10th March by R. W. Paine; (2) 400 at Garani, Gau, on 2nd April by T. H. Taylor; *"Small" sp.* (1) 100 at Koro Levu on 10th March by R. W. Paine. We are of the opinion that it is unwise to liberate less than 400 adults at any one time. A study of the habits of the adults indicates that the best time to liberate them is from a week to a fortnight after they emerge.

9. REPORTS FROM WAKAYA.

On 10th April we received a letter from Mr. de Mouncey saying that the tree on which *C. nodiceps* was liberated at Wakaya "had hundreds on." They evidently had just completed one generation. On 3rd May we received a further report from Mr. Hunt of Wakaya, who said that the tree was absolutely covered with "white bugs with many long legs." We showed him the larvae of *C. nodiceps* and he said they were certainly the same as the "many-legged" creatures. We believe these reports to be sufficiently reliable, and therefore feel fairly confident that *C. nodiceps* has become established on Wakaya.

10. RELATIVE IMPORTANCE OF THE FIVE SPECIES.

We are now in a position to estimate the relative importance of the five species in Fiji. The order of importance in Fiji as compared with that in Trinidad is probably as follows:

Fiji.	Trinidad.
(1) *C. nodiceps.*	(1) *C. nodiceps.*
(2) "Spotted" sp.	(2) *A. trinitatis.*
(3) *P. insidiosa.*	(3) *P. insidiosa.*
(4) "Small" sp.	(4) "Small" sp.
(5) *A. trinitatis.*	(5) "Spotted" sp.

It now seems very probable that *C. nodiceps* alone will do all that can be done to control the scale by natural means in Fiji, and even if the other four species also become established we are inclined to doubt whether their presence will materially increase the control. We propose to continue breeding the others if possible, but should one or more of them die out we think it would make no difference to the ultimate result. Certainly the prospects in the case of *C. nodiceps* are very good.

11. SCALE SUPPLY.

There is, as usual, much difficulty in maintaining a sufficient supply of scale. The present generation of *C. nodiceps* alone has consumed all the scale on thirty five large varas, all of which were absolutely covered with it two weeks ago. We are now satisfactorily supplementing the food supply with scale from mango trees and *Barringtonia*. Scale is still available on the coconuts beyond Cawaci. In view of the comparatively plentiful food supply present on Ovalau it seemed desirable to continue to make Levuka the centre for this work.

12. LIFE-HISTORY WORK.

We are making careful observations on the bionomics of these Coccinellids and hope within a month or so to have fairly complete records of the life-histories of at least three species.

13. ELIMINATION OF NATURAL ENEMIES.

Two internal parasites, *Tripolycystus cryptognathae* and "Coccinellid Parasite II," were found abundantly in Trinidad attacking *C. nodiceps, A. trinitatis, P. insidiosa,* and "Small" sp., and every precaution was taken both in Trinidad and during the voyage, to eliminate these parasites. Neither of them appeared on the boat from Panama to Fiji, nor after the cages were landed in Fiji, and it is certain that both were completely eliminated. This should materially increase the effect of the Coccinellids in Fiji, as compared with Trinidad.

14. CONCLUSIONS.

(1) The Trinidad Coccinellids, considered together, promise well. (2) *C. nodiceps* is almost certainly established in Fiji. (3) *C. nodiceps* is certainly the most promising. (4) Satisfactory methods of breeding all the species, except *A. trinitatis,* have now been evolved.

DEPARTMENTAL NOTES

PROGRESS REPORT OF THE EXPERIMENT STATION, PERADENIYA

FOR THE MONTHS OF NOVEMBER AND DECEMBER, 1928

TEA

A small banji experiment was started at the beginning of December in the Half Acre tea plot. Before plucking, pieces of tape were tied round 100 shoots which had produced banjis. These banjis were then all plucked. Subsequent examinations will be made to see if these shoots produce banjis again or good flush.

RUBBER

The New Avenue Rubber has been used for a number of years for field trials in various cover crops. As this rubber is now ready to tap and provides the only uniform block on the station containing a sufficient number of trees for a manurial experiment, all the cover crops were cut out in December to render conditions more even for an experiment to be started in April, 1930.

CACAO

A heavy crop was picked in November. Pepper cuttings were planted throughout the cacao areas against all dadaps not already planted with pepper.

COFFEE

The annual treatment was given in December to the sub-divisions of plot 140 E which receive cattle manure, mulch, and plain forking respectively. Up-to-date the yields from this experiment are as follows :—

Year	Yield of fresh berries per bush. 140E (1) Cattle manure forked in lb.	140E (2) Heavy mulch. No forking. lb.	140E (3) Plain forking. lb.
1921 - 22	1·78	1·94	1·10
1922 - 23	(No yield; bushes collar pruned)		
1923 - 24	·16	·13	·17
1924 - 25	1·52	1·86	2·32
1925 - 26	2·66	3·08	3·85
1926 - 27	9·25	7·51	7·88
1927 - 28	4·93	4·72	6·22
Total	20·30	19·24	21·54

The cattle manure would not appear to have exerted any appreciable benefit as regards yield.

The following is a statement of the yields of coffee grown on the station up to the end of the coffee year 1927-28.

ROBUSTA TYPES.

Year	Robusta.	Uganda.	Quillou.	Canephora.	Hybrid.
	Yield of fresh berries per bush.				
	lb.	lb.	lb.	lb.	lb.
1923-24	2·37	3·43	6·91	3·01	8·38
1924-25	4·01	5·29	3·43	3·88	5·62
1925-26	3·23	2·06	3·91	3·09	9·78
1926-27	8·54	8·99	5·01	10·29	7·61
1927-28	5·57	6·86	13·45	7·63	8·26
Average	4·74	5·33	6·54	5·88	7·93

It is noticeable that Quillou which failed in 1926-27. to give the exceptional yield given by the other varieties has given a remarkable yield in the succeeding year.

LIBERIAN TYPES.

Year	Excelsa.	Abeokuta.	Liberia Pasir Pogor.
	Yield of fresh berries per bush.		
	lb.	lb.	lb.
1923-24	5·65	9·16	6·68
1924-25	19·82	12·84	11·34
1925-26	14·00	15·26	11·71
1926-27	25·80	18·94	21·21
1927-28	19·75	17·77	12·76
Average	17·00	14·79	12·74

GREEN MANURE AND COVER PLANTS.

Immediately after planting *Dolichos Hosei* in plots 151—154 the flatter portion was divided into 18 plots. Three of these received a dressing of superphosphate, three of basic slag and three of lime, while nine plots were left as controls. The *Dolichos Hosei,* however, failed in all plots so that no information could be deduced from the experiment.

One third of Hilltop Rubber was planted with *Dolichos Hosei* along the terraces. Every alternate pair of runners was planted in holes filled with jungle soil, while the intervening pairs were planted in the existing soil.

Snakes have been troublesome in the *Indigofera endecaphylla* in the tea and a plucker was recently bitten. Though fortunately the bite was not serious this is the second occurrence of the kind and the harbouring of snakes may in some localities prove one of the most serious objections to the establishment of a ground cover in tea.

In plot 174 (young budded rubber), where a thick cover of *Centrosema pubescens* has been established for some time, weeding was only done round the trees for two months. At the end of this period the plot was so badly infested with sensitive weed that its eradication by forking cost Rs. 18/- per acre. It is doubtful if this expenditure conferred an equivalent value of the rubber, but that portion of the station is so badly infested with sensitive weed that it was thought desirable to undertake the work in order to check its spread.

In the Economic Collection a number of *Gliricidia maculata* trees have recently died. The Mycologist reported that the trees had died as the result of a collar rot and that *Sphaerostilbe repens* was found in the diseased tissue. The roots appeared healthy.

FIBRES

Half an acre of *Hibiscus sabdariffa* var. *altissima* (Roselle) was cut and the fibre extracted. This will be sent to England for valuation and report. A full report will be issued later.

THE ECONOMIC COLLECTION

A number of trees and plants have recently flowered for the first time and it is thought that the ages at which these plants flowered at Peradeniya may prove of interest.

Nutmeg, *Myristica fragrans,*	flowered	in	7	years
Cinnamon, *Cinnamomum Zeylanicum,*	,,	,,	2	,,
Kola nut, *Kola acuminata,*	,,	,,	7	,,
Annatto, *Bixa orellana,*	fruited	,,	2	,,
Pumelo, *Citrus maxima,*	,,	,,	7	,,
Croton, *Croton tiglium,*	,,	,,	2	,,
Sandal wood, *Santalum album,*	,,	,,	6	,,
Gambier, *Uncaria gambier,*	,,	,,	1	,,

Mauritius hemp, *Furcrea gigantea,* poled in 7 years from the time of planting suckers.

Sisal hemp, *Agava rigida* var. *sisalana,* poled in 4 years from the time of planting suckers.

MISCELLANEOUS

Two cases of Derris cuttings, one creeper known as Tuba tedong and one erect plant known as Tuba rabut, were received from Sarawak. About fifty per cent. of the cuttings have struck in each case.

THE IRIYAGAMA DIVISION

The majority of the stumps in the first area which were cut down to two inches in September have shot satisfactorily. Vacancies in the seedlings planted in addition to the stumps were supplied with spare basket plants.

The planting of another four areas of ten acres each was completed with basket plants in November. Three of these areas were completely planted with seedlings of the same tree. In the last area seeds of two trees had to be used. Any spare basket plants from the same parent tree were planted in the same holes as the other plants in their appropriate areas. No supplying of these areas will now be possible till the 1929 seed season when seeds of the same tree will again be available. The holing of these four areas had to be done before terracing as the land was only cleared in August and planting had to be completed in the north east monsoon. The original plan was to terrace the whole area, but subsequently it was decided to adopt the following procedure :—one portion to be terraced, on one portion drains with a gradient of 1 in 40 to be dug leaving blocks every twelve feet, one portion with similar level drains, and one portion with drains with a gradient of 1 in 40 with silt pits. In the two portions with drains of 1 in 40 the holes were dug in lines sloped at that angle and a drain put in afterwards between each row of trees twenty feet apart. The terracing was almost complete by the end of December and good progress was made with the draining.

Centrosema pubescens was planted all over the completed terraces. Holing for fence posts was started at the end nearest Gannoruwa village and a number of posts cut in readiness.

T. H. HOLLAND,
Manager,
Experiment Station,
Peradeniya.

DEPARTMENT OF AGRICULTURE

SOUTHERN DIVISION

AGRICULTURAL COMPETITIONS, KALUTARA DISTRICT, 1928-29

SMALL RUBBER GROWERS' COMPETITION.

A competition for rubber plots of one acre but not more than five acres in extent in two classes of over five years old rubber and under five years old rubber will be held in Adikari pattu for *bona fide* villagers who are neither owners nor lessees of more than ten acres of land.

The prizes will be as follows :—

Class 1.—Plots of rubber over five years old.

1st Prize	...	Rs. 20-00 and Certificate.
2nd Prize	...	,, 7-50 and Certificate.

Class 2.—Plots of rubber five years old or less.

1st Prize	...	Rs. 20-00 and Certificate.
2nd Prize	...	,, 7-50 and Certificate.

CONDITIONS.

1. Each entrant for the competition must be a *bona fide* villager who is neither an owner nor a lessee of more than ten acres of land.

2. Each plot entered for the competition must be at least one acre but not over five acres in extent, and in Adikari Pattu, Raigam Korale.

3. Competitors must send in their names to the Divisional Agricultural Officer, Southern Division, Galle, through the Mudaliyar of the Pattu, the Chairman of their Village Committee, or the Agricultural Instructor, Bandaragama, before January 1, 1929.

4. The following are the points on which the plots will be judged :—

		Points. Class 1.	Class 2.
1.	Fencing and draining of plots	10	10
2.	Prevention of soil erosion by means of terracing and growing of cover crops	10	20
3.	Distance of planting	10	20
4.	Use made of cover crops and root exposure	15	20
5.	Manuring	15	20
6.	Treatment and prevention of diseases and application of disinfectants	15	10
7.	Tapping	15	—
8.	Cleanliness of utensils	10	—
		100	100

5. The preliminary judging will be carried out by the Agricultural Instructor, Bandaragama, and the final judging of the four best plots in each class by the Divisional Agricultural Officer or his representative in conjunction, if possible, with an unofficial agriculturist in August, 1929.

W. C. LESTER-SMITH,
Acting Divisional Agricultural Officer,
Southern Division.

October 26, 1928.

REVIEWS.

THE AGRICULTURAL DEVELOPMENT OF ARID AND SEMI-ARID REGIONS.

THE book* which has recently been published under the above title deals with the subject as it affects the agriculture of South Africa although the agricultural practices of arid and semi-arid regions of Bombay, Australia and the United States are discussed. The author, who is the Professor of Agronomy at the Transvaal University College, has written an extremely interesting and lucid account of the agricultural development, problems and future of South Africa. He concludes that South African farming "must remain predominantly pastoral in character" and that "the provision of an adequate supply of feedstuffs to supplement the poor natural pasturage will always be one of the country's major problems."

Recommendations for future development include the establishment of a Dry-land Investigation Office in the Union Department of Agriculture to conduct research on specific problems of erosion, plant introduction, crop and fodder varieties and costs of production.

Some of the writer's observations are of particular interest to Ceylon. For example, he states that "the development of farming in this part of India (Bombay) supplies a warning as to the necessity of devising a form of land tenure which will obviate excessive land fragmentation." And again in discussing land tenure he says: "Share-farming in the Union is very unsatisfactory. The practice of giving land to natives on shares has made it the convention to ask so large a portion of the out-turn (usually one third or a half) that only the poorest class of white farmer will enter into the contract; the low standard of living of the native enables the latter to undertake it. In consequence, share-farming is not only synonymous with bad farming, but it has not played the part in development that might well have been expected of it."

For regions of lower rainfall the more drought-resistant crops like the millets, sorghums and flint maize are advocated together with oil seeds like sesamum. These crops with cotton, legumes, chillies and kurakkan will form the chief crops in dry regions in Ceylon and there is large scope here as in South Africa for improving existing varieties and introducing new ones.

On the question of the use of soil mulches to conserve moisture the author quotes the following pertinent passage: "Numerous experiments made in connection with this work have furnished an abundance of evidence to show that when vegetative growth is restrained the loss of water from a mulched surface is practically the same as from an unmulched one. The cheapest and most efficient methods of weed destruction necessarily form a soil mulch. The results accruing from the prevention of weed growth have been very generally attributed to the mulch itself, when the mulch is, in fact, only incidental." The American investigations which have shown this are not yet sufficiently widely known. Where animal or tractor-drawn implements are used for controlling weeds a mulch is inevitably formed but where weeds are absent there is no point in preparing a soil mulch to prevent evaporation; and where hand weeding is practised in dry regions the soil should be disturbed as little as possible.

This book will be found valuable not alone to those connected with South African agriculture; it will appeal to all interested in dry-farming. Its price is rather high.

L. L.

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* *The Agricultural Development of Arid and Semi-arid Regions*, by H. D. Leopan, Professor of Agronomy, Transvaal University College; *South Africa Central News Agency Ltd.*, 1928, pp. 280. £ 1 5 0 nett. (Obtainable from Messrs. Plâté Ltd. Colombo.)

TROPICAL AGRICULTURE.

THE scarcity of accurate and comprehensive text books of tropical agriculture has always been, and is still, very noticeable and the reason is without much doubt the magnitude of the subject. Text books of temperate field crops are comparatively numerous and many are exceedingly good. They generally manage to include a sufficiently full account of the main crops in the space of three to five hundred pages. This space appears to be totally inadequate for dealing with the crops of tropical regions. The latest book on the subject* attempts to deal with all the crops grown in the tropics in a space of 445 pages and the difficulty of doing this will be realised when it is found that rice, for example, although the author acknowledges it to be the world's most important crop, is dismissed in a little more than two pages. Seven pages are devoted to tea and about twenty each to coffee, sugar, citrus fruits, rubber and coconuts. There are short chapters on cacao, the pineapple, plantains, other tropical fruits, oil palms, fibres, grains and forage, root-crops, tobacco and spices. Other chapters deal with less widely known crops like kola (from *Cola acuminata*) and chicle which is obained from *Achras Sapota* and is used in making chewing-gum.

It is pleasing to note that soil erosion and cover plants are discussed, even if briefly, under general principles of tropical agriculture although the well-known covers *Indigofera endecaphylla, Calopogonium mucunoides* and *Mimosa invisa* are not mentioned.

The sub-title of the book is "A popular treatment of the practice of agriculture in tropical regions, with discussion of cropping systems and methods of growing the leading products." The author who is the agricultural director of the Department of Agriculture and Labor, Porto Rico, has devoted most attention to plantation crops.

Amongst the large amount of frequently up-to-date information which has been accumulated there occur many statements which are either misleading or incorrect. It is stated that "Most tea gardens are set about 5 by 5 feet, some 4 by 4, some 6 by 6, about 2,500 to 4,000 bushes to the acre." But only the planting distance 4 by 4 supplies a number of bushes (2722) within the range given and before 4,000 bushes are reached a planting distance of 3 by 3½ ft. is necessary. A common planting distance is, of course, 3 by 4 ft. It is also stated that tea bushes are pruned two or three times a year which is certainly not so in Ceylon, and that steam is used for withering the leaf. The account of tapping rubber is confused, misleading and incomplete.

Some mistakes in nomenclature occur. *Vigna oligosperma* and *Dolichos Hosei* are given as two distinct cover plants whereas *D. Hosei* is the revised name for *V. oligosperma*. Napier grass should be *Pennisetum purpureum*.

Although the book is only of small value to the specialist planter it serves a useful purpose in giving a bird's-eye view of the importance of tropical agriculture and of the steadily increasing part it plays in the economy of the temperate regions of the world.

L. L.

**The Tropical Crops* by Otis Warren Barrett, *The Macmillan Co.*, 445 pp., 17 shillings, 1928.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st DECEMBER, 1928.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st. 1928	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	851	200	96	700	23	32
	Foot-and-mouth disease	3330	65	3324	6	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	10	...	7	2	...	1
	Rabies*. (Dogs)	2	...	...	1	...	1
Colombo Municipality	Rinderpest	1809	391	136	1567	105	1
	Foot-and-mouth disease	291	...	281	10	...	...
	Anthrax	1	...	...	1	...	...
	Rabies (Dogs)	62	...	...	...	...	62
Cattle Quarantine Station	Rinderpest	77	...	43	34	...	...
	Foot-and-mouth disease	77	...	73	4	...	...
	Anthrax	...	...	..	...	...	...
Central	Rinderpest	...	...	...	..	...	...
	Foot-and-mouth disease	2831	248	2733	20	77	1
	Anthrax	...	...	...	...	...	...
	Black Quarter	39	...	...	39	...	...
	Rabies (Dogs)	21	8	...	18	...	3
Southern	Rinderpest	11	...	1	10	...	...
	Foot-and-mouth disease	282	114	267	2	13	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	9	...	6	3	...	...
Northern	Rinderpest	9	9	4	3	1	1
	Foot-and-mouth disease	2656	...	2571	85	...	...
	Anthrax	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	3436	1845	2866	19	551	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	..	...	...	...	...
	Foot-and-mouth disease	3907	5	3867	33	5	2
	Anthrax	...	...	...	...	...	...
	Rabies (Horses)	3	...	...	3	...	...
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	4217	55	4143	19	55	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	47	...	47	...	...	...
	Anthrax	...	...	..	...	...	...
Sabaragamuwa	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease	2904	192	2723	90	181	...
	Anthrax	...	..	...	..	...	...
	Haemorrhagic Septicaemia	23	6	2	21	...	...
	Pleuro-Pneumonia (in Goats)	28	...	1	27	...	...

* A Dog and a Calf.

G. V. S. Office,
Colombo, 10th January, 1929.

G. W. STURGESS,
Government Veterinary Surgeon.

METEOROLOGICAL
DECEMBER, 1928.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction during Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	79·4	+0·8	80	6·7	N	127	8·78	16	+ 3·48
Puttalam	78·4	+1·2	84	6·4	NNE	97	3·50	10	— 2·75
Mannar	79·6	+1·2	80	7·3	N	238	5·02	14	— 2·74
Jaffna	77·7	+0·6	84	6·8	NE	87	8·01	17	— 2·32
Trincomalee	78·3	+0·4	85	6·6	NNE	167	8·98	23	— 5·08
Batticaloa	78·6	+1·2	84	7·0	N	195	9·13	19	— 7·53
Hambantota	79·2	+0·6	83	5·0	ENE	228	1·57	11	— 3·77
Galle	79·0	+0·9	83	7·4	Var.	131	5·59	8	— 1·14
Ratnapura	80·3	+1·2	78	6·1	—	—	7·25	13	— 1·74
Anu'pura	77·3	+0·3	81	7·0	—	—	6·69	14	— 2·01
Kurunegala	79·5	+1·3	78	7·7	—	—	1·80	10	— 5·42
Kandy	75·6	+1·5	80	6·1	—	—	9·07	16	+ 0·16
Badulla	71·0	+1·2	88	6·7	—	—	10·51	22	— 1·74
Diyatalawa	65·3	+0·4	86	7·0	—	—	8·23	16	+ 0·44
Hakgala	60·6	+0·7	88	7·6	—	—	6·12	21	— 7·42
N.' Eliya	59·0	+1·8	68	7·4	—	—	4·17	15	— 4·24

The rainfall of December was on the whole decidedly below average. There was a fair amount of rain during the first ten days, but after that very little (except possibly on the 19th) till X'mas. There was rather more during the last week, but not enough to bring the totals for the month up to average in the majority of cases.

The highest total reported was 24·49 at Keenakelle and other totals of over 20 inches were at Hendon, St. Martin's, Deanstone and Ledgerwatte. These figures are, however, below the December averages of the stations concerned. The highest fall in a day was 8·62 inches at Mawarella on the 29th and others over 6 inches were at Kiran and Kirimutty, north of Batticaloa, on the 25th, and at Mihintale on the 27th.

The average was reached however at stations in the northern parts of the Western Province and Sabaragamuwa and a few adjacent stations in the N.W.P. and C.P., also in the centre of the S.P. and at one or two stations in Uva and the Jaffna Peninsula. The biggest excess were at Vadamarachchi and Negombo where the averages were passed with over 8 and 6 inches to spare respectively.

A. J. BAMFORD,
Supdt., Observatory.